Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN

JOURNAL OF SCIENCE.

EDITORS

JAMES D. AND EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS JOSIAH P. COOKE, GEORGE L. GOODALE AND JOHN TROWBRIDGE, OF CAMBRIDGE.

PROFESSORS H. A. NEWTON AND A. E. VERRILL, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA.

THIRD SERIES.

VOL. XLII.—[WHOLE NUMBER, CXLII.]

No. 251.—NOVEMBER, 1891.

WITH PLATES XIII–XV.

NEW HAVEN, CONN.: J. D. & E. S. DANA.
1891.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

SCIENTIFIC BOOKS.—MINERALS.

Some Rare and Valuable Books from the largest stock of Scientific and Medical books in the World. Send for catalogues specifying in what branch you are interested.

Says. Entomology, edited by LeConte, 2 vols. 64 plates plain, $5.00, colored edition, $8 50.

Agassiz. Echinodermes, 2 vols. 63 plates, 4to. and folio. $7.50.
Bureau of Ethnology, 6 vols. Colored plates, 4to. 1879 to 1885. $12.50.
Cuvier. Animal Kingdom, edited by Griffith, Pidgeon, et al., 16 vols. 799 plates. $20.00.
Pacific R. R. Survey, 13 vols. $12.50.
American Journal of Science and Arts, 138 vols. $275.00.
Hayden, U. S. Geological Survey. Monographs, 12 vols., 4to. $27.50.
Wheeler's U. S. Geological Survey, 8 vols., 4to. $20.00.
U. S. Geological Surveys. Annual Reports, 10 vols., 4to. $12.50.
Baird, Cassin & Laurence. Birds of North America, 2 vols. $5.00.
Holbrook, North American Herpetology, 4 vols. $75.00.
Agassiz. Contributions to Natural History of U. S., 4 vols., 4to. $25.00.
Popular Science Monthly. Complete set to 1890. $35.00.
Humphreys & Abbot. Physics and Hydraulics of the Mississippi, 20 plates, 4to. $3.50.
American Naturalist. Complete set to July, 1891. $60.00.
Elliott, Botany of South Carolina and Georgia, 2 vols., 1824. $7.50.
Nature. Complete set to 1890. $50.00.
Pennsylvania Geological Survey, 100 vols. $35.00.
Baird, Brewer & Ridgway. North American Birds, 3 vols., 64 plates, 593 illustrations, 4to, 1874. $20.00.
Bischoff, Chemical and Physical Geology, 3 vols. 1854–1859. $10.00.
Lowe and Howard. Beautiful Leaved Plants. 60 colored plates, 1872. $5.00.
Sowerby, Recent and Fossil Shells. 264 plates, 1825. $15.00.
Torrey, Botany of New York. 161 plates, 4to. $7.50.
Shaw & Stephens. Zoology, 28 vols. 1200 plates, fine calf. $20.00.
Hayden, Geological Atlas of Colorado. Folio, 1878. $3.50.
King, Exploration of 40th Parallel, 9 vols., 4to, and folio complete. $40.00.
Pursh, Plants of North America. 24 colored plates. $10.00.
Coffin, Winds of the Globe, 4to. $5.00.
Lowe, British and Exotic Ferns, 8 vols., 479 colored plates, 1880. $20.00.

CHRISTMAS PRESENTS.

The systematic collections that we put up are very attractive as well as instructive. The hard wood boxes add much to the desirability of the collections for presents to young people. Many a child might have its tastes turned to natural history by even the 50c. collection which is very pretty.

NUMBER OF SPECIMENS.	25 in box.	50 in box.	100 in box.	100	200	300
Crystals and fragments, ¾ in	$ 50	$1 00	$2 00	$1 00	$2 00	$4 00
Student's size, larger, 1½ x 1½ in	1 50	3 00	6 00	5 00	10 00	20 00
Amateur's size, 2¾ x 2 in				10 00	20 00	45 00
High School, or Academy size, 2½ x 3½ in., Shelf Specimens				25 00	50 00	125 00
College size, 3½ x 6 in., Shelf Specimens				50 00	100 00	250 00

Petrified wood (described last month), **garnets** from Alaska, Salida and many other localities, **opals** from Mexico and elsewhere and many beautiful species for presents for collectors can be supplied.

Meteoric Iron from Cañon Diablo in complete pieces from 25c. upward. This is the cheapest and most interesting meteoric iron ever sold.

Matlockites, Phosgenites from England. We have received from the collection of a gentleman recently deceased at the locality the finest specimens ever offered for sale in this country. They are priced lower than the price paid the men at the locality. **Anglesites** from the same locality and some yellow from Fresno, Utah, just determined.

A. E. FOOTE,
4116 Elm avenue, Philadelphia, Pa., U. S. A.

THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

Art. XXXIV.—*The Solution of Vulcanized India Rubber;* by Carl Barus.

1. Introductory.—In my work* on the solubility of glass in water, I showed that in proportion as the state of dissociation or the molecular instability of glass is increased with rise of temperature, the solvent action of water increases at an enormously rapid rate; that inasmuch as the solution takes place between a solid and a liquid, sufficient pressure must be applied to keep the fluid in the liquid state, whenever the vapor tension at the temperature in question exceeds the atmospheric pressure. Thus, at 100°, the action of liquid water on glass is nearly negligible; but even at 185° solution occurs at so rapid a rate that capillary tubes may become filled with solid hydrated silicate, in place of water, in an hour. Here, however, about 10 atm. must be applied to keep the solvent in the liquid state essential to speedy reaction.

2. *The present application.*—Having attempted to apply the same principle to the actual solution of vulcanized India rubber, I obtained confirmatory results at once. To my knowledge this material has not heretofore been advantageously dissolved in a volatile reagent, or in any reagent by which it is speedily and copiously taken into solution, and from which it may be conveniently obtained. Cf. § 4, note.

It follows by analogy from § 1, that the rubber must be hot enough to be in a state of dissociation, i. e., that the coherence of the rubber-sulphur molecules must show an instability in regard to whatever solvent may be used. It follows, more-

* This Jour., xxxviii, p. 408, 1889. Ibid. xli, p. 110, 1891.

over, that the system of rubber and solvent is to be kept under pressure sufficient to insure the liquid state of the solvent. It follows obviously that this temperature must only be so high, cæt. par., as to change in the least degree possible, the useful character of the rubber eventually to be deposited from solution. Hence, I act on vulcanized India rubber at the lowest convenient temperature facilitating the solvent action, and at a pressure preferably exceeding the vapor tension of the solvent at the given temperature. Whatever other favorable action pressure may exert (such, for instance, of forcing the fluid into the physical pores of the semi-solid by a principle akin to Henry's law) is clear gain. In my machine* it is rather more convenient to act under 100 atm., or more, than at lower pressures. Hence I did not scruple to use pressures as large as, or above, this, testing the adequacy of low pressures, however, by special experiment. §§ 18, 20.

The samples of vulcanized rubber acted on were five in number, and their character may be detailed as follows:

a. Very elastic† sheet rubber, usually not pigmented, translucent in thin films, brownish in color, used for rubber bands and sheeting, chemical rubber tubing, etc.

b. Less elastic and harder rubber, pigmented gray, opaque, largely used for rubber tubing, etc.

c. Non-elastic, pigmented rubber, flexible, opaque gray, used for low class rubber tubing and low class merchandise in general.

d. Ebonite.

e. Same as *a*, rotted by age and exposure.

3. *Solution in carbon disulphide.*—From experiments made at 100° and 160°, it appears that elastic sheet rubber (*a*), is not fully soluble in CS_2 in a reasonable time, if at all. It is quite soluble at 185°, and soluble to a remarkable degree and at a remarkably rapid rate at 210°. Hence the pressure under which solution is to take place, should here be greater than

* See Proc. Am. Acad., xxv. p. 93, 1890, or Phil. Mag., October, 1890, p. 338. The present method of work is simple: Glass tubes 10^{cm} to 15^{cm} long, and $\cdot 3^{cm}$ or $\cdot 4^{cm}$ in diameter, closed at one end, and drawn out to a capillary canal with three enlargements at the other, were filled with a charge of vulcanized rubber and solvent, and then introduced into the steel piezometer tube. I made use of the temperatures of boiling turpentine (160°), aniline (185°), naphthalene (210°), and diphenylamine (310°). To separate the charge from the oil of the piezometer which transmits pressure, I first employed a thread of mercury inserted into the capillary canal. Finding, however, § 17, that this metal acted on the charge, I replaced it by a thread of water, or contiguous threads of gasolene and water. Charges were usually introduced in the ratio of one part by volume of rubber to three or more of solvent, § 18. About 1^{cc} to 2^{cc} of solution were obtained per heating. I made considerably over 150 experiments, most of them at 210° and 100 or 200 atm. Experiments on a larger scale were also made in great number, chiefly with the object of studying the product deposited from solution. § 20.

† By elastic I mean extensible with resumption of the original shape when the pull ceases.

15 atm., but need not exceed 30 or 40 atm. Inasmuch as CS_2 thus unites with rubber in any proportions, clear brown solutions of any viscosity may be obtained. Diluting such (thick) solutions with cold CS_2, the solvent is first greedily absorbed; but the final complete solution of the unagitated syrupy rubber takes places very slowly. Finally, by exposing any of the solutions to air, the CS_2 evaporates, and the dissolved vulcanized rubber is regained without sacrifice of its original non-viscid quality. Similarly fissured brittle sheet rubber or tubing (*e*), which has become useless for practical purposes by age, is quite soluble in CS_2 at 200°, so far at least as its undecomposed portion is concerned. Elastic gray rubber (*b*), dissolves completely to a gray liquid, in which the pigment is suspended. § 16. The concentrated solution hardens at once on exposure to air, reproducing a rubber of nearly the qualities (*b*). The same is true of the non-elastic sample (*c*). Treatment at 310° resulted in a decomposition of the rubber.

Commercial ebonite (*d*) is first partially devulcanized at 200°, (excess of rubber) and eventually dissolves in excess of solvent. The partially devulcanized product is elastic on drying, but finally hardens to a tough solid having a leathery quality. The solution leaves a black stain, with free sulphur apparent after evaporation. § 15. Gases are frequently evolved during solution of highly vulcanized rubber in CS_2. §§ 17 and 19.

As a whole my experiments show that excess of sulphur is first removed by the solvent, after which the vulcanized rubber itself passes into solution. § 15.

4. *Solution in liquids of the paraffine series.*—The elastic rubbers (*a* and *e*) dissolve easily in liquid mineral oils, at 200°. The pressure necessary will, of course, vary with the boiling point of the oil used, and may be as high as 50 atm. in the very volatile gasolenes. Commercial gasolene, though a good solvent of the rubbers *a* and *e*, is less powerful in case of *b* and *c*, unless excess of solvent be used. On exposure to air, the gasolene evaporates, leaving a residue which soon hardens. Mineral oils of a higher carbon order than gasolene, petroleum,* for instance, dissolves the rubbers *a* and *e* even more easily. The solution, however, dries only after much time and probably only in thin films. Solubility seems to increase as the oil lies higher in the carbon series. §§ 12, 18.

* Looking up the literature of the subject, I found that John J. Montgomery (Cf. Letters Patent No. 308,189, November, 1884, U. S. Patent Office), describes a process for the solution of vulcanized rubber. His statement of the temperature and pressure necessary are substantially correct, although he confines his experiments to a petroleum oil boiling at 200° or higher. The oil is subsequently driven off by injections of steam. This is the nearest approach to an available and true solution (a solution which does not remain permanently sticky like the turpentine and other solutions) which I have found. The essential peculiarity of the methods in the above text is solution in volatile solvents.

5. *Solution in turpentine.*—In case of the elastic rubber (*a*), complete solution is at once effected at 200°, whereas at ordinary temperatures the time necessary is enormous, if indeed the solutions in the two cases be the same. The syrupy liquid obtained at 200° seems to dry in very thin films. Special experiments made at 160° showed that no reasonably speedy solution takes place even in liquid turpentine at this temperature, thus corroborating the inferences of §§ 1, 2, 3. Gray rubber (*b*) is acted on with greater difficulty at 210°. The solution leaves a white glossy stain which hardens. Pressure need not exceed 5 atm.

6. *Solution in chloroform and carbon tetrachloride.*—Elastic sheet rubber (*a*) dissolves at once in liquid $CHCl_3$ at 210°. Pressure should exceed 15 atm. and need not be larger than 25 or 30 atm. Solutions of any degree of viscosity seem to be obtainable. They dry at once on exposure to air, leaving a hard residue relatively dark in color. Possibly this was due to the presence of sulphur in the chloroform. § 15. Gray rubber (*b*) is attacked with decomposition of the solvent and evolution of gas.

7. *Solution in aniline.*—Solution in the liquid at 200° takes place at once, in case of elastic rubbers (*a*). Pressure need not exceed a few atmospheres. Thin films apparently dry on long exposure.

8. *Solution in animal oils.*—Neither in the case of sperm oil, nor of lard oil was the elastic rubber (*a*) dissolved on removing from the piezometer. Both distintegrated on standing, to a solution, often with slow evolution of gas.

9. *Treatment with glycerin.*—At 200° no solution occurs. Glycolic alcohols were not examined. Cf. § 12.

10. *Solution in benzol and higher aromatic hydrocarbons.*—The elastic sheet rubber (*a*) dissolves at once in liquid C_6H_6 at 200°. Pressure should exceed 7 atmospheres, but need never be higher than 30 atm. The solution exposed to air hardens rapidly. Solution of gray rubber (*b*) is less easy.

Solution of elastic rubber (*a*) in liquid toluol at 200° also takes place with great ease. The liquid dries slowly. Pressures of less than 10 atm. suffice.

11. *Solution in ethylic and higher ethers.*—Elastic sheet rubber (*a*) dissolves at once in liquid ethylic ether at 200°. Pressure should exceed 25 atm., but need not be greater than 40 or 50 atm. The solution hardens immediately on exposure to air. Gray rubber (*b*) is attacked with difficulty.

12. *Treatment with alcohols.*—At 200° india rubber (*a*) is not dissolved in liquid methyl or in liquid ethyl alcohol, and only slightly so in liquid amyl alcohol. Thus, again the solubility seems to increase with the molecular weight of the solvent. § 18.

13. *Treatment with ketones.*—India rubber (*a*) treated with liquid acetone at 200°, is converted into a sticky paste from which it hardens at once on exposure to air. Pressure should exceed 15 atm., but need not be greater than 30 or 40 atm.

14. *Treatment with water and mineral acids.*—In no case was there a trace of true solution at 210°. Water probably enters the physical pores of the elastic rubber (*a*), as this substance becomes superficially rough and warty on drying in steam at 200°, after being treated with liquid water at the same temperature. It does not melt. § 18. Strong hydrochloric acid (1 : 2) has no obvious effect, while strong sulphuric acid (1 : 3) seems only to char the rubber. Treating gray rubber (*b*), with HCl, I found its solubility in CS_2, C_6H_6 and gasolene to have decreased.

15. *Treatment for vulcanization. Liquid ebonite.*—Liquid ammonic polysulphide at 185° or 200° does not change the appearance of gray rubber (*b*) markedly; but the sample loses its elasticity and shows a semi-plastic consistency. This I believe to be due to additional vulcanization induced by the polysulphide. If now the sample be treated with liquid CS_2 at 200°, the solvent is decomposed with the evolution of much gas, and the rubber restored to its original elastic quality. The gas is liberated throughout the mass of the rubber, and the sample, when taken out of the tube, has the form of an enormously inflated cellular sack, which issues from the glass tube explosively, but soon collapses on exposure to air. As a whole these results agree with the behavior found for ebonite in § 3. In both cases it is possible to pass from a more vulcanized to a less vulcanized solvent by treating an excess of rubber. It will be shown below, § 19, that the gas evolved is probably due to the double decomposition of water and CS_2.

More interesting is the direct vulcanization of a rubber solution, to liquid ebonite, by aid of a solution of sulphur. In case of elastic sheet rubber (*a*), this even begins at 160°; but it is more complete at 185° and 210°. In case of pure (non-vulcanized) rubber dissolved in CS_2 with excess of sulphur, scarcely any change of the flesh color is observed at 160°, and the sulphur crystallizes out of the solvent in needles, on exposure. At 185° and 210°, however, the charge turns black, showing complete vulcanization. If equal masses of vulcanized rubber (*a*) and sulphur be treated, the product, after heating to 210°, is not dissolved nor soluble, until the excess of sulphur is removed. §§ 3, 15. Gas is often evolved. §§ 17, 19. In proportion as less sulphur is used relatively to the rubber, the product becomes more immediately soluble and less gas is evolved. Adding about 20 per cent of dissolved sulphur to the elastic rubber (*a*), I obtained serviceable solutions of ebo-

nite, on treating at 200° either in CS_2 alone, or in mixtures, § 16, of this liquid with gasolene, benzol, etc. In most cases these harden very quickly to a jet-black enamel. With less sulphur the color is brown in thin films.

16. *Solution in mixtures of solvents, and solution of mixed gums.*—By acting on vulcanized rubbers with mixed solvents of the above kind, I obtained very satisfactory results. All the rubbers mentioned (*a* to *e*), ebonite excepted, pass easily into true solution by such treatment. Thus the gray elastic rubber (*b*) dissolves at once in a mixture of CS_2 with gasolene, or benzol, or ether, etc.; or of benzol and toluol; or less easily in mixtures of benzol and gasolene; etc. Ebonite is partially devulcanized, and would probably be dissolved in large excess of solvent. § 3. No gas was evolved in any case, § 19, which is an advantage of this method. In all cases the solutions hardened rapidly on exposure to air, yielding the pigmented rubber if the solution be shaken, or a purer rubber, if the sediment be removed by subsidence and decantation.

Equally feasible is the solution of mixed gums in a suitable solvent at 200°. Thus I made solutions of mixed vulcanized rubber and gutta percha in CS_2, which dried at once on exposure to air; mixtures of rubber and shellac dissolved in CS_2, drying more slowly; mixtures of vulcanized rubber and rosin dissolved in CS_2 and in gasolene, which dried in thin films only after long exposure; etc.

17. *Direct devulcanization.*—When, by any of the above methods a solution of vulcanized rubber is obtainable, direct devulcanization may be attempted by mixing the charge with some sulphur absorbent. Such material must be chosen which at 200° acts neither on the rubber nor the solvent. Metallic filings do not appear to be available. Treating ebonite with CS_2, C_6H_6, or gasolene, to which copper filings had been added, I found the charge, after exposing to 200°, to be disintegrated, while an enormous amount of gas was evolved. Scarcely any of the solvent was left in the tube. The direct action of copper or of sulphur, on CS_2, etc., at 200° is insufficient to account for this reaction. § 19. The gas must, therefore, be produced at the expense of the ebonite, or of the reagent in presence of ebonite; and since all the solvents used behave alike, at the expense of the ebonite. This may furnish some clue as to the chemical character of the rubber as related to the gases evolved. Gaseous decomposition frequently sets in on exposure of highly vulcanized rubber solutions even to ordinary room temperatures, whereas at 0° and under slight pressure (1 or 2 atm.) the gas remains in combination. Bright steel is

scarcely attacked.* In fusing impregnated india rubber, § 18 I frequently noticed that the colder ends of the mass were opaquely discolored. Possibly, therefore, the sulphur at 200° may be gradually segregated by diffusion or evaporation. My experiments on this subject failed.

18. *Fusion of impregnated rubber.* — If vulcanized india rubber be impregnated or saturated by digesting it with the cold reagent (any solvent of pure rubber), for a suitable time (a few minutes to many hours), the swelled mass not only shows a relatively low melting point, but it remains liquid after cooling, provided the solvent is not allowed to escape. This is an observation of practical importance, since the retorts† can thus be charged with solid or dry rubber, a minimum of solvent be used in treating or lost by evaporation, and concentrated solutions be obtained often fit to be used at once. The rubber so melted hardens on exposure. Finally the pressure necessary in this case is the smallest possible, and may be below the data given for the divers solvents above.

The quantity of solvent retained by solid rubber is very large: Thus elastic sheet rubber will hold 7 or 8 times its weight of CS_2, or 1 to 2 times its weight of naphtha. Gray rubber (elastic) absorbs more than its weight of naphtha; etc.

Experiments may be cited as follows: Non-impregnated vulcanized rubbers (*a* to *e*) do not melt if exposed in a closed tube at 210°. Only in the case of very slightly vulcanized pure rubber gum is there a trace of fusion perceptible at the edges, and here it may even be due to a stain of dirt (oil) accidentally left there. Gray rubbers (*b*, *c*) with a superficial coating of exuded sulphur, turn black from the formation of a film of ebonite.

All the india rubbers (*a* to *e*) fuse at 210°, when previously saturated, or nearly so, with cold carbon disulphide, and exposed in a close-fitting glass tube. If the pressure be reduced by a capillary aperture at one end of the otherwise closed glass tube, or if the tube be only partially filled and the empty end kept cool, the impregnating solvent is merely distilled off, and no fusion takes place. Whereas at 160° fusion scarcely occurs, melting seems to be complete in the well impregnated elastic rubber (*a*) at 175°. There is therefore an approximate coincidence of the thermal data in the present and in the above paragraphs.

* Fortunately, therefore, steel apparatus is available on a large scale. An interesting question occurs as to what becomes of the carbon, in the case where sodium, mercury, copper, etc., are attacked by hot liquid CS_2 and not by cold CS_2.

† The present experiments were made in *closed* glass tubes, nearly filled with the impregnated rubber. After fusion the mass frequently appeared to have shrunk. Cf. § 2.

Similar results were obtained with benzol, with gasolene and higher petroleum oils, etc. Fusion is absent or only incipient at 160°, and more than complete at 210°, provided the gasolene be not too volatile. §§ 4, 12. In general the gray rubbers (*b*, *c*) fuse to a more viscous mass than the gum rubbers (*a*), the consistency of cold solutions in the latter case about that of treacle.

The occurrences of this paragraph therefore would resemble the fusion of a salt in its water of crystallization, but for the exceptional behavior that impregnated vulcanized rubber after fusion retains a consistency which is liquid relatively to the original non-impregnated charge. The analogy with the solution of starch, or of gluten, is thus more close and immediate. In all these cases the solid swells up when impregnated with the solvent, and fuses to a relatively less viscous consistency, or to a thin solution, when a certain temperature (below 100° in case of starch and gluten and above 160° in case of vulcanized india rubber) has been reached. Hence it is not unreasonable to suspect that even ordinary dry wood, or woody tissue, which swells to a marked degree when impregnated with water, may pass into actual solution if the temperature at which the water acts is sufficiently high, and the pressure above the vapor tension of water at that temperature.*

I mention finally that the reduction of melting point produced in vulcanized india rubber by the impregnating reagents may perhaps advantageously be discussed in accordance with Raoult's law; but owing to the difficulty of defining the melting point of the unimpregnated rubber, and the close proximity of the melting points after impregnation with different reagents (CS_2, C_6H_6, gasolene) my views on this subject have not taken shape. It is known that in general that the melting point produced by a dissolved colloid is relatively very small, from which an exceedingly large molecular weight of the colloid has been inferred. The above results show that in the converse experiment, where the melting point of the colloid is lowered by a solvent, the effects will probably be normal and pronounced.

Nevertheless I doubt whether the thin rubber fluids obtained are true solutions, i. e. represent a case in which the division of the solid has actually reached a definite molecule; for on

* I have since tested this surmise at some length, but found in every case that cellulose is decomposed before solution in water takes place. In spite of the presence of water under pressure, the phenomenon seems to be a dry distillation. I may here refer to the remarkably close analogies in the thermal behavior of rubber and gelatine which have recently been discovered by Bjerken (Wied. Ann., xliii, p. 817, 1891). The author has reason to believe that moist gelatines are heterogeneous mixtures of solid and liquid. The behavior of rubber, as discussed above, is characterized at low temperatures by a fixed maximum of absorbed solvent. The term mixture is scarcely applicable at once.

long standing in sealed vessels a gradual thickening of the liquid with final coagulation seems to be the invariable result. Thus there must be a gradual growing together of the individual particles, until finally the whole solution forms one coherent gelatinous mass.

To summarize: Suppose the coherence of rubber to be due to (cohesive) affinities, capable of being saturated like ordinary affinities. Then in case of impregnation with a solvent, a part of these combine with the similar affinities of the solvent. The result is the decided decrease of tenacity (observed). To liquefy the impregnated sample, the residual cohesive forces of the rubber must be withdrawn, and this can be done by heat. The liquid so obtained, I do not conceive to be a true solution, but rather a suspension of particles, the exceeding fineness of which is determined by conditions discussed elsewhere.* Diffusion is thus an excessively slow process, and hence the liquid on cooling need not become solid again. In proportion as the individual particles unite however, coagulation gradually sets in, and its structure is probably that of a fine sponge holding solvent in its interstices. If the coagulated solution be reheated (under pressure), a thin viscid solution is again obtained, which in its turn coagulates.

19. *Behavior of reagents.*—The frequent occurrence of gaseous products in the above experiments made special experiments on the decomposition of reagents necessary. Benzol and gasolene were found stable at 210°, and often above this temperature, both in the presence of water, or of sulphur. § 21. Carbon disulphide, however, in addition to relatively slight decompositions producible by sodium, or mercury, or copper (§ 17), at 210°, is doubly decomposed by water at this temperature, with the evolution of much gas, presumably H_2S and CO_2. CS_2 remains stable in the presence of zinc white (a common rubber pigment), or of sulphur, or of bright steel, at 210°. § 17. Hence a thread of mercury to shut off the experimental tubes, § 2, is generally objectionable, as is also a thread of water in case of CS_2. Moreover the absence of gaseous reaction in case of mixed solvents, § 16, is to be attributed to the fact that CS_2 and the water are intentionally separated by layers of benzol or gasolene.

An interesting question is suggested here, as to whether it be possible to express affinity on a scale of temperatures. Let it be required to determine the affinity of a metal for sulphur. At ordinary temperatures not even sodium decomposes CS_2, whereas such decomposition occurs if the temperature be sufficiently high. Hence the temperature at which the decomposition definitely sets in (for copper sooner than for iron, etc.) is

* Barus: this Journal, xxxvii. pp. 126–128, 1889.

a reciprocal expression of the affinity of the given metal for sulphur,—bearing always in mind that the stability of the solid metallic molecule also enters into the consideration. The arbitrary reagent CS_2, in its relations to all the metals to be examined, fulfills a similar purpose to an arbitrary spring balance in measuring gravitational forces. § 21.

20. *Summary of the results.*—In the above paragraphs I have therefore indicated a method by which vulcanized india rubber of any quality or character whatever, as well as the undecomposed or reclaimable part of rubber waste, may be dissolved or liquified in a reasonably short time;* the solutions possessing any desirable degree of viscosity or diluteness, from which india rubber may be regained on evaporation of the solvent.

I shall elsewhere describe divers forms of apparatus by which the above operations may be carried out on a larger scale. They are of no interest here; but I mention them since it is only from such work that a full insight into the quality of the rubber deposited from any given solution may be obtained. Experiments made in bulk in this way showed the material deposited from solution to be considerably inferior to the original rubber, both as regards tenacity and elasticity. Its chief value in the physical laboratory will therefore be that of furnishing an air-tight cement or an acid-proof varnish, capable of withstanding more than 200° centigrade. Rubber newly deposited from any of the above solutions presents a very curious case of slowly reacting elasticity. If a thread, say 0·1 cm. thick, be twisted and then let go on a frictionless surface, it will squirm like a live worm for some minutes. If it be stretched, the original length is regained with visible slowness.

Throughout my work the approximate constancy of the dissolution temperature irrespective of the solvent has been the marked feature. Thus in case of CS_2, of turpentine, of the vulcanization of dissolved pure india rubber, etc., no action took place below 160°. Even this temperature is higher than is needful for vulcanization effected in the dry way, where 110° to 140° are deemed sufficient. Moreover the solution of vulcanized rubber in CS_2, for instance, takes place quite as easily under 700 atm. as under, say 20 atm., as is particularly manifest from the fusion of impregnated rubber, and in special high pressure experiments. In my work on the compressibility of liquids† I showed that compressibility is essentially associated with the extra-molecular forces whereas the molecule remains relatively incompressible. Temperature, however, has immediate access to the molecule; and thus it follows that

* Practically at once, if the material is not too bulky.

† This Journal, xxxix, p. 510, 1890.

whereas the effect of temperature in experiments like the above is manifest, the effect of pressures of the order applied is relatively inappreciable.

21. *Digression.*—From the above paragraphs I infer that the difficulty encountered in endeavoring to dissolve carbon is probably attributable to a relatively high dissociation temperature of the solid carbon molecule. I made many experiments to test this view, in all of which I failed to obtain solution even at low red heat and 600 atm. of pressure. My work thus corroborates the negative results of Hannay* on the direct solution of carbon. My tests were made with gasolene, water, benzol and carbon disulphide, usually at 500° and 500 atm. In case of gasolene I observed at higher temperatures. Usually the reagents were decomposed (particularly CS_2, C_6H_6 and $CHCl_3$) with the evolution of much gas, while the carbon remained appreciably unaffected. Decomposition by metals (copper corroded by CS_2, and gasolene acted on by palladium) showed sooty deposits only.

ART. XXXV.—*Report of the Examination by Means of the Microscope of Specimens of Infusorial Earths of the Pacific Coast of the United States;* by ARTHUR M. EDWARDS, M.D.

SOME time since I had transmitted to me by Mr. George Gibbs, the geologist of the Northwest Boundary Expedition, a collection of earths gathered at different points on the Pacific coast of the United States in the states of Washington, Oregon and California, as well as British Columbia, with a request that I would make an examination of them by means of the microscope, the more particularly for the purpose of determining the characters of the organic remains to be found in them. Through this means I have been enabled to study and record the discovery of several deposits of minute organisms, and at the same time very materially assist in unraveling the geology of some points of the country hitherto found to be somewhat difficult of comprehension.

At the time these examinations were made, that is to say, in the latter part of the year 1861, very little was known concerning many points in the geology of our Pacific Coast, and my own experience in the study of such earths had been rather slight. Hence, when I made my report in 1862, I was unable

* Hannay: Proc. Roy Soc., lxxx, p. 188, 1880; Chem. News, xli, p. 106, 1880. Cf. Hannay and Hogarth: Chem. News, xli, p. 103, 1880; Mallet and Hannay: Nature, xxii, p. 192, 1880.

to go very fully into the subject of the evident mode of formation of the strata containing the microscopic organisms. Since that time the Geological Survey of the State of California has been undertaken and a much more extended suite of gatherings has come into my hands.

Through the knowledge acquired from the examination of these collections made at various points from Puget Sound to the southernmost border of California, I have been enabled to furnish such information that the history of both the marine and fresh water, so called, Infusorial deposits of that portion of the country has been pretty thoroughly worked out. With regard to the marine strata very little has, as yet, been published. The results arrived at concerning one class of the fresh water strata has been made known in a communication of Professor Whitney's read before the California Academy of Natural Sciences, February 4th, 1867. (Proc. Cal. Academy, vol. iii, p. 319.) These he has therein shown to be the beds of enormous extinct lakes or inland seas, the material of which has been altered in character by the superposition upon it at different periods of lava or sand and gravel or ashes and pumice. In this way it can be readily understood that, as the volcanic action ceases, a new growth of microscopic organisms might take place over the erupted material lying upon the older deposits and, in fact, that many such layers might accumulate one over the other. Such has been the case at various points upon the Pacific Coast from Puget Sound to Lake Mono in Eastern California, which is the most southern point from which I have received such material. At some future time I may have more to say with regard to this class of deposits, for I have examined many of them during the progress of the Geological Survey of California and, when my report thereon is published, I shall be enabled to go more fully into the subject. As I have several specimens from strata of this character to describe in the present report I shall, for the time being, indicate them as sub-Plutonic, which is the most distinctive appellation I can now find for them.

Among the specimens which I have examined in connection with this survey, and aside from those which do not contain any organic remains, and hence will be treated of separately, I have then, first, the sub-Plutonic, which I have just alluded to, and which are always of fresh water origin; second, the fresh water deposits of more recent formation and, in fact, which are now under process of growth all over the world beneath ponds and lakes, and which I have hitherto been in the habit of calling sub-Peat, but I have lately preferred to designate as Lacustrine Sedimentary, as I consider that they are better so indicated. Besides these two classes of deposits, which differ

from each other only in time and in the fact that in the most recent a certain amount of organic matter usually remains and the material is light and readily pulverulent. We have in the older one, on account of the volcanic heat added to, or without aqueous action, the material has had all of its organic matter removed. And it has become a less or more hard rocky mass of a light color. Hence we have strata of a totally different character. These are of marine origin and of an age supposed to be coincident with the Miocene Tertiary. At all events they are much older than the most ancient fresh water stratum containing Diatomaceæ as yet discovered. Of the mode of formation of these last mentioned strata I shall not now pause to treat, as I have already thrown out some hints respecting my opinions upon this point in some remarks made before the Essex Institute, Salem, Mass., January 4th, 1869, an abstract of which will be found in the Bulletin of that association, vol. i, page 11. I have treated of the same subject in a paper read before the American Association for the Advancement of Science, at the Salem meeting, August 25th, 1869. Hereafter I will treat fully of this subject in my report on the microscopic material of the Geological Survey of California now in preparation.

It will be readily perceived that it is fortunate that my report on the matter herein treated of was not published at the time it was sent in, and I feel that I can congratulate myself that Mr. Gibbs has again submitted the matter to me for revision, for at the present time I can do more justice to it and throw light upon some points which, at the time, I was unable to fully comprehend.

The constantly recurring records of the discovery of fossiliferous deposits containing the remains of such minute organisms as the Diatomaceæ, Radiolaria and Rhizopoda, constituting the well known 'Infusorial earths' of most geologists reveal the fact that these atomies play a very important part in the world's future; and while almost every newly found specimen exhibits one, if not more, of what have been considered new species, it proves, at the same time, the cosmopolitan character of many already known forms, which are thus seen to occur spread over the globe in great profusion from the equator to the poles. In some cases these widely-spread species will not vary appreciably, be their dwelling place under the burning sun of the tropics, the more equable climate of the temperate zone or the frozen fields of the poles. Other forms, however, on the contrary, appear to vary to so great an extent with every few degrees of latitude that specimens gathered at the equator and in localities a very little removed therefrom, either north or south, might be supposed, on superficial exam

ination, to be distinct. So markedly is this the case that we not unfrequently find that hasty observers have so classed them and even made use of locality for the determination of specific distinctions. That the Diatomaceæ, which are the organisms with which I shall most particularly treat in this paper, are extremely cosmopolitan in their habits; in fact, perhaps more so than any other group, would seem to be already established, but the imperfect state of our knowledge of them and their life-history at present, leaves us a great deal in the dark as to the full extent of their variation during the lapse of time or through local distribution. Much has yet to be done in this field of investigation and large and widely extended collections made of both the recent and extinct forms, before we can assert that we know anything very certain with regard to their position in the chain of being, their habits, history, or range of variations in time or space. I do not, at the present time, desire to go more fully into this branch of the subject, merely confining myself to a thorough report upon the specimens submitted to me by Mr. Gibbs. The student who desires to follow researches in a field which will yield profitable returns cannot choose for himself one in which less is known, perhaps, than this, and when its applications to geology are considered, for my part, I can hardly imagine one more enticing.

Below I give a list of the specimens sent to me for examination by Mr. Gibbs and which were collected by him during the prosecution of the Northwest Boundary Survey.

* Hot spring, Harrison's lake, British Columbia.
Nahchess river, Washington.
Alkaline deposit, Similkamen river, Washington.
* Steilacoom creek, No. 1, Washington.
* " " No. 2, "
* Point Roberts, "
* Bluff west of Camp Simiahmoo, Washington.
* Camp Simiahmoo, No. 1, Washington.
* " " No. 2, "
* " " No. 3, "
Winass river, "
* Point Ludlow, "

Those localities marked with asterisk (*), are from the west or coast side of the mountain range, while the others are from the eastern slope. This is a point of importance and to be borne in mind as will be shown farther on. The principal point to be decided in examining these specimens was whether they contained any traces of organic remains by means of which their marine or fresh water could be determined. Therefore they were first superficially examined so as to note if any

such remains appeared and those that showed signs of yielding definite results were set aside for further study after they had been properly prepared. In this way all of the specimens submitted to me were examined.

Most of them were found to contain no traces of organic remains by means of which might be ascertained their origin, as desired. The presence of the siliceous skeletons of Diatomaceæ in any earth, or deposit of any kind reveals at once the fact that such a deposit has formed beneath the surface of water or, if the remains are not evenly distributed throughout its mass, it may have been overflowed by water having Diatomaceæ living in it. Besides this, it may be also ascertained as to whether it has been thrown down from fresh water or in the ocean. Although this branch of the subject has not received the attention that its importance deserves yet we can with some considerable degree of certainty even determine as to whether the water from which such a deposit was thrown down was a lake, a bog or marsh, an estuary or the open ocean. As the matter comes to be more fully studied and the knowledge of facts is increased we shall doubtless be able to determine these and similar points with a greater degree of accuracy.

The indestructible nature of these skeletons, on account of their consisting mainly if not entirely of silica, deposited during the life of the plant in its tissues, preserves for the student of nature a record of former aqueous submergence, and, as their distinctive characters are not very difficult of recognition by careful students we thus have typical forms of organisms to use for the purpose of determining the marine or fresh water origin of any specimen under examination. At the same time it must be remarked that by far the greatest portion of the time that has been spent by most observers on the Diatomaceæ has been evidently mainly for the purpose of discovering new forms rather than ascertaining the life-history or even the distinctive characters of already known species. So that our lists have become but a heterogeneous mass of mere names applied to often accidental, sometimes distorted or even fractured specimens. I can not too earnestly enter my protest against the recognition of the species-monger as a naturalist; such observations and records as those I allude to do not only not advance our knowledge but certainly retard its progress by placing new obstacles in the path of the student of nature. Elsewhere I have spoken more fully on this subject and shown how it is that this branch of biology has fallen undeservedly into disrepute among scientific naturalists; at the present time I will refrain from saying more than I have already put upon record.

From what has been said with regard to distinguishing the origin of a deposit by means of the minute remains present in it, it will be readily understood that we can thus determine to a certain extent its age, as to whether the overlying water has been fresh, brackish or salt. In the last case we shall find present such oceanic genera as Triceratium, Coscinodiscus, Aulacodiscus, or Actinocyclus. If the source of the deposit has been the shallow water along shore we should expect to find littoral species among which would be some of the Pleurosigma or Amphiprora; often, of course mixed with deeper water forms or even fresh water varieties accidentally mixed by being washed down from elevated stations. On the other hand if we find the genera Tabellaria, Cocconema or Himantidium to be present, the fresh-water origin of the gathering is established. So a group of mixed marine and fresh-water species would indicate the formation of such a deposit under very peculiar circumstances, but such mixtures are extremely rare. One of the few of this character which I have seen being a gathering of living specimens from the St. Johns river in Florida, which on account of its course being nearly North and South, is so affected by the tides that the marine species of Diatomaceæ at least are carried up almost to its head. At some future time when the life history of these minute forms is better understood observers will doubtless be able to ascertain from the examination of gatherings of the siliceous skeletons whether they have grown and been deposited in a lake, river or brook, near the level of the sea or at high altitudes as well as the fact of the fresh or salt character of the water. In fact I feel convinced that a time will come when this mode of study applied to deposits generally will reveal many circumstances connected with the formation of most of the strata constituting the available mass of the earth. At the present time so little is known of certainty with regard to the life-history of the Diatomaceæ: the attention of observers having been mainly turned towards the finding of new forms and manufacturing them, when found, into so-called species, that little can be stated definitely with regard to their distribution or habit. For years I have been engaged in gathering material to illustrate this point and I am in hopes that, as facilities for collection increase valuable information will be accumulated. With regard to the mixture of forms considered peculiar to fresh or salt water respectively, a case of supposed mixing of species in a lake into which the ocean had access at certain periods of high tides is recorded by Dr. Gregory in the celebrated 'Glenshira sand,' as it has been called, and such may have been the circumstances under which this deposit was thrown down for we have an example of a similar phenomenon

in the case of the Mystic Pond, near Boston, Mass. Here the bed of the pond is much below that of the river which serves as its outlet, so that at the time of high tides the salt water, which on account of its superior density creeps up beneath the fresh water, runs over the bar at the entrance and flows down into the pond, thus mixing the forms of life found therein. An account of this locality with a list of the forms of Diatomaceæ observed in the mud brought up from the bottom of the pond by Messrs. Greenleaf and Stodder will be found in the Proceedings of the Boston Society of Natural History, vol. viii, page 119. So also I have examined a locality of a like kind upon Phillips' Beach between Swampscott and Marblehead, Mass. Here a small mass of fresh water fed at uncertain periods by intermitting streams, by drainage or by infiltration of water through the beach sand, by which the salt is removed, lies a short distance within and at a lower level than the shore and in it grow many fresh water plants and are found several fresh water animals. Yet at times of high tide or during storms the salt water must find egress, for in it I observed marine species of Diatomaceæ in the mud taken from the bottom and, in fact, some few were noticed living in the water of the pond.

The microscope thus applied to geology, in the hands of experienced and competent observers, besides the above, reveals the fact as to whether a gathering under examination be of recent origin, deposited in a pond, lake, river, marsh, bay, or ocean in existence at the time; or contain mostly extinct forms or be situated in time below the alluvial, and hence to be classed among the truly fossil strata. So that by means of such an examination we come to classify specimens containing Diatomaceæ according to the age or mode of occurrence of these forms, and I have provisionally grouped my gatherings into, first: Recent, both marine and fresh water; second, Lacustrine sedimentary, now forming, although in many cases dating their period or origin as far back as the Post-Glacial. The recorded occurrences of similar deposits of fresh water forms in the Tertiary I consider extremely doubtful; third, we have then the deposits to which I have given the distinctive title of sub-Plutonic and the mode of occurrence of which I have alluded to above; fourth, thereafter and lastly we have the true Marine Fossiliferous strata which, as far as recorded, have been found only in the Lower Miocene Tertiary. A subdivision of some of these groups is convenient; as, for instance, the recent gatherings may be so arranged as to indicate the peculiar habitat of the species contained in it; the so-called "natural leathers" and "paper;" the soundings from

the sea-bottom or shell cleanings, as well as harbor muds, the contents of the intestines of marine and fresh water animals and the like be indicated. However, I think that nearly all gatherings may be fairly grouped under the four heads I have adopted.

As the tendency of most persons who have turned their attention to the Diatomaceæ, which are the organisms I shall more particularly consider in this report, has been towards looking for differences where similitudes should have been searched after, I must be permitted to say a few words on that point. The progress of time, the more especially if it be very much extended, may, and in fact will, so change the apparent characters of all living organisms that they can hardly, in the present condition of our knowledge, be distinguished one from another; but they will most assuredly revert to the parent type, even if the modifying influence be continued in power, so strong, so persistent, so fundamental is the inherent germ-force implanted in the individual. The Diatomaceæ are not so liable to be influenced by outward circumstances, apparently, as some other groups; but, at the same time, understood energies do affect them very materially, so as to change their outline, for instance, leaving their main characters of sculpture intact. I very much doubt if time has as great or as lasting an effect in causing such modifications as locality and, therefore, must consider the use of this point as a basis for distinguishing species to be unscientific and unjustified, at least with regard to these organisms.

Among the specimens I have to report upon herein, we have examples of all of the four groups I have adopted, as Recent, Lacustrine, Sedimentary, and sub-Plutonic, under which head are to be placed the tripolis of commerce and Marine Fossil strata.

The first Lacustrine Sedimentary deposit discovered in this country was that found by the late Prof. J. W. Bailey at West Point, N. Y., and was described by him in volume xxxv of this Journal. Since that time similar deposits have been discovered at many widely separated points in this country and in Europe, which bears out the opinion expressed by Prof. Bailey that strata resembling the West Point earth in general characters would be found under every bog in the country. In Europe such has been the case, as the Lough Mourne, Premnay, Peterhead, Toome Bridge and Mull in Great Britain and others on the Continent bear testimony.

After receiving from Mr. Gibbs the collection of specimens I have already given a list of, he also sent three more, and these I shall include here, as they come from the same portion of country as the first. They are marked as below:

* Shookum Chuck, a branch of the Chihalis river which flows into Gray's Harbor, Washington.
* Colseed Bay, Hood's Canal, Washington.
Pit River, eight miles from Fort Crook, Cal.

These may all be supposed to belong to the western or coast slope of the mountain range, although Mr. Gibbs says that that from Pit river, the eastern branch of the Sacramento, may belong to either side.

Of the fifteen earths but seven were found to contain the remains of Diatomaceæ.

* Hot Spring, Harrison's lake, B. C.

This consists of a saline mass evidently deposited by the hot spring, but contains no organic remains.

Nahchess river, Washington.

No organic remains.

Alkaline deposits, Similkamen river, Washington.

This specimen is of very much the same general character as the first.

* Steilacoom Creek, No. 1, Washington.
* Steilacoom Creek, No. 2, "
* Point Roberts, Washington.
* Bluff west of Camp Simiahmoo, Washington.

No organic remains.

* Camp Simiahoo, No. 1, Washington.

A lacustrine sedimentry deposit, containing:

Amphiprora navicularis. Gomphonema intricatum. Himantidium bidens. Himantidium gracile. Melosira varians. Pinnularia major. Pinnularia viridis. Pinnularia mesolepta. Stauroneis anceps.

Camp Similkamen, No. 2, Washington.

No organic remains.

* Camp Similkamen, No. 3, Washington.

A lacustrine sedimentary deposit, containing:

Amphiprora navicularis. Cocconema leptoceros. Cocconema lanceolatum. Cymbella ?. C. ?. Gomphonema (Pinnularia) amphioxys. Gomphonema olivaceum, Himantidium arcus. Himantidium biceps. Himantidium bidens. Himantidium ?. Navicula elliptica. Navicula cuspidata. Navicula amphigomphus. Nitzschia (Synedra) spectabilis. Orthosira distans. Pinnularia gigas. Pinnularia dactilus. Pinnularia nobilis. Pinnularia mesolepta. Pinnularia viridis. Pinnularia tabellaria. Pinnularia Johnsonii. Pinnularia ?. Stauronies phœnicenteron. Surirella craticula.

Amphiprora navicularis is the one Ehrenberg has given that name to and is quite common in lacustrine sedimentary deposits in this country although I do not remember ever to have seen it anywhere else. The form I have called *Nitzschia spectabilis* evidently belongs to that genus and appears to be identical with *Synedra spectabilis* C. E. Wenish (Syn. Brit. Diat. 1853, 139), who describes a form as *Nitzschia scalaris* W. S., thus claiming the authorship, although he gives *Synedra scalaris* as the original form and Kützing as the founder. The fact is that *Synedra scalaris* was founded by Ehrenberg (Amer. 137, II, ii, 18) and his form was from freshwater at Surinam, and Andover, Conn. A form answering to it in every way is not uncommon in this country in both the recent state and in deposits. It varies much in size and in coarseness of its markings but always preserves essentially the same characters. I cannot see in what particulars *Synedra scalaris* differs from *Synedra spectabilis* except in size, a character which can hardly be considered specific. I prefer to group all of these forms together.

In this specimen *Himantidium soleirolii* occurs with the internal cells described by Ralfs in the Quart. Jour. of Mic. Sci., vi, 14, and which peculiarity has also been seen in Meridion and Odontidium.

Winass River, Washington.

A hard white mass not readily broken down and contains no organic matter, that having been burned out; in fact it is a specimen of the kind of strata I have mentioned above which Prof. Whitney has shown to have been affected by volcanic heat. On the Columbia River these strata were found for the first time by Fremont and examined by Bailey who however did not understand their distinctive character. They are of particular interest as having been hitherto only found on the Pacific shore of this continent. Nowhere else apparently have there existed such enormous masses of fresh water which have become dried up by the elevation of the country, through volcanic agency and subsequent hardening of the material constituting their beds by the action of lava. This particular specimen is made up for the most part of one species of Cyclotella and there are present a few individuals of *Odontidium mesodon*, *Orthosira punctata* and *Orthosira arenaria*.

* Point Ludlow, Wash. A sub-Plutonic deposit containing:
Cyclotella rotula. Epithemia granulata. Pinnularia major. Pinnularia ?. Orthosira orichalea. Surirella ?.

* Skookum Chuck, Wash. A sub-Plutonic deposit containing:
Cocconeis placentula. Cocconema cymbiforme. Cocconema lanceolatum. Cyclotella Kützingiana. Cymbella Ehrenbergii. Encyonema cœspitosum. Epithemia adnata. Epithemia gibba.

Epithemia gibberula. Epithemia granulata. Gomphonema dichotomum. Odontidium mutabile. Orthosira ?. Pinnularia ?. Synedra capitata. Synedra radians. Tabellaria flocculosum.

* Colseed Bay, Hood's Canal, Washington. A lacustrine sedimentary deposit containing:

Cocconeis placentula. Cyclotella rotula. Epithemia adnata. Epithemia luna. Gomphonema vibrio. Melosira ?. Navicula elliptica. Navicula ?. Pinnularia major. Pinnularia ?. Orthosira orichalea. Odontidium ? Tetracyclus ?.

Pit River, 8 miles from Fort Crook, Cal. A sub-Plutonic deposit.

Amphora ovalis. Cyclotella Astrea. Cyclotella rotula. Cymbella ?. Cymatopleura elliptica. Fragillaria striatula. Gomphonema capitatum. Gomphonema constrictum. Gomphonema ?. Epithemia gibba. Epithemia luna. Surirella splendida. Surirella linearis. Tetracyclus lacustris. Stauroneis punctata. Pinnularia major. Orthosira ?. Navicula cuspidata.

Having now given the results of the examination of the first parcel of earths submitted to me by Mr. Gibbs I will point out some of the results arrived at. Bailey having had sent to him several specimens of so-called 'infusorial earths' as those brought home by Fremont, Blake and others, ascertained, as he supposed, that all of those collected upon the eastern slope of the Sierra Nevada Mountains were of fresh water origin, while those from the Coast Range contained the remains of Diatomaceæ only. It became interesting, therefore, in examining the specimens put into my hands to ascertain if therefrom I was prepared to confirm or refute this assertion of Bailey's, upon which, of course, geologists had depended for drawing deductions. Up to the time of the publication of the paper of Professor Whitney in the Proceedings of the California Academy, which I have alluded to, the true character of these sub-Plutonic deposits was entirely misunderstood. And this arose, doubtless, to a certain extent, from their occurring only in one portion of the world where naturalists have traveled little and where the microscope as applied to geology has as yet not made much progress. But the lacustrine sedimentary, or sub-Peat, deposits are found all over the world and have been much examined by microscopists. That these and the first mentioned should have been classed together and neither of them understood is, perhaps, not so surprising when we consider that few microscopists are naturalists; that instrument having been too often used as a toy and not employed as an instrument of research. It is not to be wondered at perhaps that Bailey did not comprehend the origin and geological position of these two classes of strata and it is to be hoped that what I have said herein will at least

help to prove interesting upon this point. Both of these classes of deposits have been called 'fossil,' but if either of them can be properly so designated it must be the sub-Plutonic one alone; the others are of recent origin and identical deposits are now undergoing formation all over the world. Thus, all through the New England States they are very common. At Bemus Lake, in New Hampshire, the bed of that piece of water when stirred up by means of a pole is seen to be almost white in color and consist entirely of the dead shells of Diatomaceæ. As Bailey's conclusions, although they had been founded upon extremely slight foundations, had been accepted by geologists generally it came to be asserted that no fresh water deposits of Diatomaceæ were to be found upon the coast side of the Sierra Nevada, only marine strata being there seen and not extending to the western slope of the mountains. Hence, it became of interest to determine whether the deposits discovered since Bailey's time in that part of the country bore out his theory or not, and this was one of the questions put to me when these specimens were placed in my hands.

As will be seen, all of the seven deposits which I found to contain the remains of Diatomaceæ, in the above mentioned collection, are of fresh water origin, three of them being decidedly of recent formation, or lacustrine sedimentary, and the other four from the beds of extinct lakes, or sub-Plutonic. It will also be noted that all of them with the exception of one, that from Winass River, are from the western side of the mountains, that one being from the east. However, from what I have already said respecting the mode of formation of these fresh water strata containing Diatoms it will be understood that but little of geological value attaches to the examination of such strata by means of the microscope unless they are proved by other evidence to be of greater age than the present period. So that my examination even taken for what the results obtained are worth does not bear out Bailey's theory.

The second parcel of earths which I received for examination were for the most part collected by Dr. J. S. Newberry during prosecution of the survey of the Colorado River by the expedition under the command of Col. Ives, and also while connected with the Pacific Railroad Survey under Lieut. Williamson. They were as below:

	1.	26.	Shores of Lower Klamath Lake, borders of Oregon and California.
*	2.	23.	Monterey, Cal.
*	3.	1.	San Francisco, Cal.
*	4.		San Diego, Cal.
*	5.	55.	Pit River Valley, Cal.

* 6. 56. Near Monterey, Cal.
* 7. 53. Pit River, Lower Cañon, Cal.
* 8. 54. Pit River, Lower California.
* 9. 60. Monterey, Cal.
* 10. 57. Monterey, Cal.
* 11. 58. San Francisco, Cal.
* 12. 54. Pit River, above Lower Cañon, Cal.
* 13. Dalles of the Columbia, Oregon.
* 14. 28. San Diego, Cal.
* 15. 9. San Pablo Bay, Cal.
16. 516. Black Cañon, Colorado River, Cal.
17. 506. "White Rock," Colorado River, Cal.
18. 519. "White Rock," Colorado River, Cal.
10. 496. "White Rock," Colorado River, Cal.
* 20. 17. Monterey, Cal.
* 21. 24. Monterey, Cal.
22. 155. Psucseeque Creek, Oregon.
* 23. Monterey, Cal.
? 24. 907. [Smithsonian Catalogue.]
* 25. San Joaquin Valley, Cal.

I have indicated the geographical position of the localities in this list, as far as known, in the same manner as employed in the preceding catalogue, that is to say, those marked with a star (*) are from the western side of the mountains, while the others, with the exception of No. 1, 20, which is from the gap between the Sierra Nevada where it joins the Cascade, which is a portion of the Coast Range, are from the east of the slope.

1. 26. Shores of Lower Klamath Lake, borders of Oregon and California.

The position of the bed from which this specimen was taken and its relation to the overlying trap will be understood from what Dr. Newberry has said in his report on the geology of this section of country. (P. R. R. Report, vol. vi, part II, Geology, pp. 37 and 38.) It is sub-Plutonic.

Cyclotella rotula. Epithema granulata. Orthosira orichalcea. Pinnularia viridis.

* 2. 23. Monterey, Cal.

Of this as well as those numbered No. 3, 4, 6, 9, 11, 14, 15, 21, 23, and 25, I will speak hereafter together, as they all came from the same strata of the Miocene Tertiary.

* 5. 55. Pit River Valley, Cal.

From a sub-Plutonic deposit. On the banks of the Pit River these so-called "infusorial marls" present a very strikingly peculiar appearance and often modify very greatly the character of this whole tract of country. Dr. Newberry (p. 32) has pointed out the characters of this district and, in

connection with the examination of these specimens it may be of interest here to quote somewhat from his report. He says that 'they appear on both sides of Pit River at intervals of several miles, being in many places interrupted or covered by the beds of clay. They are perhaps best exposed in the cañon formed by the passage of the river through 'Stoneman's Ridge,' the most conspicuous of the lines of upheaval, which form what is known as the lower cañon of Pit River. They here exhibit a thickness of about fifty feet, but are considerably tilted up, and covered by a thick bed of trap, which has been poured out over them. In some places this alternation of Diatomaceous deposit and trap is often repeated as, for example, on the Psucseeque Creek, a tributary of the Des Chutes River; the bank is capped by hard columnar trap and beneath this are successive strata varying in thickness and forming steps of thirty to forty feet wide. These steps, which at this point number twelve, have been formed by the more ready wearing away by weathering of the 'infusorial' deposits, they being protected above and below to a certain extent by layers of tufa, concrete or trap. These deposits represent the enormous extinct fresh water seas which at one time extended over a large part of our continent. Those who are interested in the subject will find more particulars in the sixth volume of the Pacific Railroad Survey, in the paper by Professor Whitney I have alluded to above, and in a paper read May 16, 1870, before the New York Lyceum of Natural History by Dr. J. S. Newberry and published in the Proceedings for that month. I found the following:

Amphora ovalis. Cyclotella operculata. Cyclotella rotula. Epithemia granulata. Gomphonema intricata. Orthosira granulata?. Pinnularia nobilis.

* 8. 54. Pit River, Lower Canon, Cal. A sub-Plutonic deposit.

Campylodiscus?. Cocconema lanceolatum. Cocconeis pediculus. Cyclotella rotula. Cyclotella operculata. Encyonema cœspitosum. Epithemia granulata. Gomphonema cœspitosum. Gomphonema intricatum. Orthosira punctata. Pinnularia nobilis. Surirella?.

This deposit, together with No. 5. 55. agree in many respects with some infusorial earths described by Bailey in vol. xvii, of this Journal for March, 1854. The earths he describes were sent to him by Lieut. Robert Williamson and were collected in Oregon and California. In fact one of Lieut. Williamson's earths is labelled "Pit River, Washington Territory," and agrees with the two deposits described above and marked Nos. 5. 55. and 8. 54. as I have ascertained from

personal examination of the original material in the Bailey Collection, Boston.

* 10. 57. Monterey, Cal.

A sub-Peat deposit of *Melosira varians* with sporangia. There are small quantities of *Synedra radians*, *Nitschia linearis* and *Fragillaria virescens*.

* 13. Dalles of the Columbia, O.

A sub-Peat deposit containing sand and *Orthosira punctata*.

* 20. 17. Monterey, Cal.

A specimen of a Miocene, Oligocene or Eocene Tertiary as is proved by the shells of Foraminifera contained in it.

* 2. 23. Monterey, Cal.
* 3. 1. San Francisco, Cal.
* 4. San Diego, Cal.
* 6. 56. Near Monterey, Cal.
* 9. 60. Monterey, Cal.
* 11. 58. San Francisco, Cal.
* 14. 28. San Diego, Cal.
* 15. 9. San Pablo Bay, Cal.
* 21. 24. Monterey, Cal.
* 23. Monterey, Cal.
* 25. San Joaquin Valley, Cal.

These specimens are evidently gatherings made at different parts of a marine fossiliferous deposit discovered by W. P. Blake and described by him in the Proceedings of the Philadelphia Academy of Natural Sciences, vol. vii, page 328 for 1854–5. The locality is mentioned as being about two miles distant from the town of Monterey and the stratum is revealed on the side of a hill some 500 to 600 feet high, consisting for the most part of this white 'infusorial earth' interstratified with compact siliceous layers of a dark material supposed to be bituminous in character. The earth is similar in most of its characters to the celebrated stratum underlying the city of Richmond, Virginia. The Diatomaceæ agree very closely with those of Richmond, Petersburg, Piscataway and Nottingham deposits which extend from the Patuxent River in Maryland to Petersburg in Virginia. The genera most largely represented are:

Actinocyclus.
Actinoptychus.
Arachnoidiscus.
Asteromphalus.
Aulacodiscus.
Auliscus.
Biddulphia.
Campylodiscus.
Coscinodiscus.
Creswellia.
Gephyria.
Grammatophora.
Isthmia.
Navicula.
Rhabdonema.
Triceratium.

Thus then we have described seven new fluviatile fossiliferous deposits from Oregon, California and Washington, four of which are from the Western side of the mountains, one from the gap and one from the east, proving that the freshwater deposits are confined to neither side of the mountains. The Monterey deposit is marine Miocene Tertiary.

New York, 1870.

NOTES ON THE ABOVE.

The deposit from Lake Mono, Cal., to Winas River, Wash., are parts of the same, and it extends from Winas River, Wash., on the north and Lake Mono, Cal., on the south to Great Salt Lake, U., on the west. That is to say the most northern point I have it from is Winas River, Wash., and the southernmost point is Mono Lake, Cal., on the west and Great Salt Lake, U., on the east. They were investigated by I. C. Russell (U. S. Geological Survey, 1885), in Western Nevada when he described "Lake Lahontan," which includes Honey Lake, California, Humboldt, Pyramid, Winnemucca, North Carson, South Carson and Walker Lakes, Utah; by C. K. Gilbert (U. S. Geological Survey, 1890), when he described "Lake Bonneville," which includes Great Salt Lake and Sevier Lakes, Utah, and at Mono Lake, California, by I. C. Russell, which includes two or three little lakes. (U. S. Geological Survey, 1886-7.) The three are made separate lakes by Gilbert but when we look at a map of the Great Basin we see they are all one. This one great lake or Occidental Sea extends from Washington on the north to Arizona on the south, and California on the west to Utah on the east. The country is flat, making the Great Plain of Fremont, and this great freshwater sea is shown by the Diatomaceæ composing the freshwater marls, of a white or nearly white color, which in some places, as at Psucseeque Creek, are twelve in number, and intercalated with lava which flowed from the volcanoes of the Lassen's Peak district over the whole extent of surface. At the same time the country was raised and earthquakes were common and are still common and the Sierra Nevada is rising now. This sea was drained into the Pacific Ocean, first by the Colorado, and afterwards by the Columbia, and subsequently the Klamath, Pit, Feather and San Joaquin rivers. It was bounded by the Rocky Mountains on the east and the low range of mountains made up principally by the Coast Range on the west. The species of Diatomaceæ present are *Lysigonium oricalcheæ* M. (*Gallionella distans* C. C. E.) and *Cyclotella operculuta* C. A. A. (*C. Kützingiana* T.) mixed with several other species in small quantity. But the Lysigonium and Cyclotella are common and always present. Thus showing that it was a lake of still water, for these species now grow in freshwater lakes and not in running water or in the ocean.

My reasons for making this one Occidental Sea and including Mono, Honey, Lower Klamath, Goose, Clear, Upper and Middle in Modoc Co., Eagle Horse and Swan Lakes in California; Upper Klamath, Rhett or Tule Wright, Christmas or Warner and Maleur Lakes in Oregon; Chelan, Great Salt, Utah, Sevier Lakes in Utah and Red Lake in Arizona besides several small lakes in these States, are the finding of one or two species of Diatomaceæ in the freshwater marls as two and sometimes twelve strata interstratified with lava. The flat plain, the Great Plain of Fremont, whose rocks are present as faulted monoclines over the surfaces, takes in the eastern portion of California, three-quarters of Oregon, half of Washington nearly the whole of Idaho, all of Utah and Arizona and half of New Mexico and perhaps extends into Mexico.

Whether this includes the Sacramento and San Joaquin Rivers, that empty by way of the Golden Gate into the Pacific Ocean is doubtful, but extremely likely, as the Sierra Nevada is later in time of formation than the Coast Range. Tulare Lake, Cal., the sink of the Kern River, is also most likely the end of an Intraglacial deposit. But this has not been geologically investigated.

The geological period of the Occidental Sea is most likely Oligocene Tertiary though Gilbert places "Lake Bonneville" in the Pleistocene. That is to say "Lake Bonneville" was finally dried out in the Pleistocene. The Occidental Sea was formed and the freshwater marl laid down in the early Tertiary.

This determines, of course, that the species are confined to the ocean, brackish or freshwater. Some experiments I am making would seem to point to the fact that the Diatomaceæ originated in freshwater and were carried down to brackish water and so to the sea. Brackish forms, as *Nitzschia scalaris* C. G. E. have been seen growing in great profusion in a freshwater pond without any outlet, and brackish forms, as *Amphiprora alata* C. G. E., *Amphora aponina* F. T. K., *Bacillaria paradoxa* G., *Cyclotella operculata* F. T. K., *Fragilaria capucina* L. W. D., *Melosira nummuloides* F. T. K., *Navicula minutua* W. S., *Nitzschia angularis* W. S., *N. dubia* W. S., *N. linearis* W. S., *N. reversa* W. S., *Shizonema conferta* W. S., *S. crucigera* W. S., *S. Smithii* C. A. A., *Surirella ovata* F. T. K., and *Synedra tabulata* F. T. K. have been grown in freshwater. The concentration of freshwater in the western lakes, as at "Lake Bonneville" and "Lake Lahontan" have resulted in brackish water.

Newark, N. J. 1891.

Art. XXXVI.—*The Tonganoxie Meteorite;* by E. H. S. Bailey. With Plate XIII.

[Contributions from the Chemical Laboratory of the University of Kansas, No. II.]

In "Science" of Jan. 2, 1891, Dr. F. H. Snow published a preliminary notice in regard to the discovery of the Tonganoxie meteorite. The specimen was picked up in 1886, by Mr. Quincy Baldwin, on his farm a mile west of the town of Tonganoxie, Leavenworth County, Kansas. The true nature of the specimen was not understood by the original owner. He experimented with it so far as to make a fish hook from a fragment of it, and thought its occurrence was an indication that there was an iron mine on his farm. Since, however, he was unable to find any more specimens, the iron mine theory was abandoned. Mr. Baldwin disposed of the meteorite to Mr. H. C. Fellow, then Principal of the Friends' Academy in Tonganoxie, and from him it has been purchased by Dr. Snow and it is now in the Museum of the University of Kansas.

The specimen originally weighed a little over twenty-six pounds, but a slice has been cut from the smaller end, in order to obtain a plane surface, that the structure might be studied, and the present weight is twenty-three and one-quarter pounds [10·55 kilos.] Its shape is that of an irregular triangular pyramid; the length being 9½ inches, the width 6½ inches, and the depth 4½ inches. The specific gravity is 7·45, as compared with water at its greatest density. This specific gravity was taken by weighing the whole meteorite.

As can be seen by an examination of fig. 1, the surface of the meteorite shows numerous depressions, some of them quite large. The entire exterior is covered with a reddish black coating. This seems to be composed of scales of oxide of iron. These scales are brittle and readily attracted by the

magnet. After the specimen had been for some time exposed to the air, after being handled, numerous droplets of chloride of iron appeared on the surface. These seem to exude from minute cracks or to come from under the scales. The occurrence of chloride of iron, and its exuding in this way, is by no means uncommon in meteorites. To the fact of its presence is probably due the great tendency to scale noticed above. This iron salt gradually changes to a brown friable oxide.

The analysis shows the following composition:

Iron	91·18
Nickel	7·93
Cobalt	0·39
Phosphorus	0·10
Copper	a trace
	99·60

A test made for sulphur, on the same sample analyzed above, showed only a possible trace, but an examination was made of a sample of turnings, somewhat oxidized, and a very perceptible precipitate of barium sulphate was obtained. Scattered over the polished surface may be seen occasional long slender crystals, sometimes branching, and also several nodular masses, of a bronze color. These are without doubt troilite; [iron-nickel sulphide]. The larger particles are near the center of the polished end, as though the last to crystallize. The troilite cannot be seen till the surface has been polished with oil and emery. As this mineral is so irregularly distributed there was probably only a very small quantity in the particular piece analyzed. The Widmanstättian figures came out very perfectly with nitric acid. Figure 2, reduced one-fifth from a photograph, shows the characteristic forms The octahedral form of crystallization is apparent, but it is not possible to distinguish the Neumann lines, that are believed to indicate the cubic form of crystallization. It is however possible, as some observers have noted, that some other surface, if polished, would show this form. A crack extends across the surface on the etched side, and other small cracks lead into it. These are all filled with a black mineral, probably made up of the oxidized metals. The cracks in an irregular way follow the lines between the crystals.

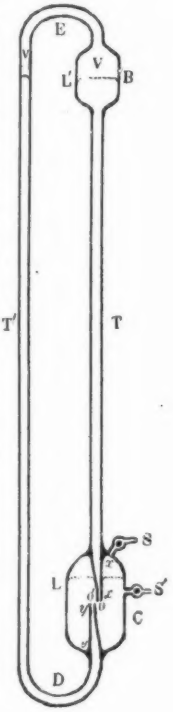
On examining this meteorite with the magnetic needle, it was found that there were several distinct poles. Mr. A. G. Mayer has plotted the lines of magnetic force, so as to show their true relation. The position of the poles might be expected to be near the ends, but this is not the case in this specimen.

As the meteorite is irregular as described, and quite flat and comparatively free from cavities on one side, the question naturally arises, is it not a fragment thrown off from a much larger mass. A careful examination of the mass will render such a theory, to say the least, very probable, but whether this mass was brought here by human or geologic agencies, or whether its companions still exist in the vicinity, it is at present impossible to state. A careful search in the vicinity of the farm where it was found, fails to reveal any other specimens.

University of Kansas, July 10, 1891.

Art. XXXVII.—*Proposed Form of Mercurial Barometer*; by W. J. Waggener.

The form of barometer to be described in this paper is shown in the accompanying figure. It should be made with all its parts of glass united into a single piece in the form of a tubular loop having two dilatations, B and C; the latter serving as cistern. S and S′ are two carefully made stop-cocks connecting the cavity of C with the atmosphere. Through S, the atmospheric air is to be admitted when the instrument is in use. *xx* and *yy* are prolongations of the tubes T and T′ into the cistern, their openings, *o*, *o*′, being very near together and to the center of the cistern. The capacity of the latter should be about four times that of the vacuum, Vv, so that the openings *oo*′ shall always be immersed in mercury whatever the position of the barometer.



To prepare the instrument for use, the manipulations will be as follows:

1. Place it in a nearly horizontal position and fill the whole cavity with mercury.
2. Close the cocks and place the instrument in the erect position.
3. Open the cock S. Mercury flows out, the Torricellian vacuum forming at E, C remaining filled with mercury.
4. Close the cocks tightly and leave the barometer for some time, first in the erect, afterward in other positions, so that the air and moisture of the cavity may enter the vacuous space.

5. Regarding the instrument as in the figure, rotate it around the line of sight and in the plane of the paper, thus causing any air or vapor accumulated in the vacant space to pass into the cistern, whence it can no more pass into other parts of the cavity.
6. Repeat the foregoing manipulations in order, until the vacuum in V is as nearly perfect as possible. (Probably No. 1 need not be repeated often.)

Doubtless the apparatus would work well if made without the return tube T′ and its prolongation *yy*, being sealed at D and E; but the complete loop has evident advantages, among which is the fact that it allows the tubes to be of small bore without impeding the flow of the mercury and the transfer of air-bubbles, thus greatly diminishing the amount of mercury required.

The principal features of this construction occurred to me some two years since, but my attention was taken from it by other matters until recalled by reading an account of the method proposed by G. Guglielmo,* this method being essentially the same as that involved in the foregoing manipulations; but his apparatus seems to me less perfect and convenient than that described above. He claims that this method gives better results than that of boiling the mercury, but it is evident that heat can easily be used with the loop form of tube, if desired.

Boulder, Colorado, July 29, 1891.

ART. XXXVIII.—*Color Photography by Lippmann's Process;* by CHARLES B. THWING, Evanston, Ill.

IN a communication to the Académie des Sciences on the second of February last, M. G. Lippmann opened an entirely new line of experimentation on the problem of the photographic reproduction of the colors of nature. To Lippmann's account of his discovery is appended in Comptes Rendus a note by Mons. Edw. Becquerel to the effect that the process of Lippmann differs radically from the discovery made by himself in 1848, in that while Becquerel was able by photo-chemical means to produce a colored image of the spectrum which could not be exposed to light since the action of the usual fixing agents reduced the deposit to a mere film of metallic silver, Lippmann, on the other hand, had by a physical process obtained an image which retains its colors after treatment with hyposulphite of soda, and is, therefore, as permanent as an

* Atti della reale Accad. dei Lincei, August, 1890.

ordinary negative. The peculiarities of Lippmann's method consist, first, in the use of a plate which is transparent and free from grains; second, in the exposure of the plate with its film side resting against a reflecting surface of mercury. The interference of the reflected with the incident ray of light divides the film into a number of layers at the maxima which will correspond in their distance apart with the wave length of the incident light, and will, therefore, be able to reproduce by reflection the color which produced the layers.

Lippmann says that the plates are positive for reflected and negative for transmitted light (négatif par transparence). By negative he means showing the complementary color. In that one of Lippmann's negatives which I have seen and all those obtained by myself, the plates are opaque to transmitted light, showing only differences of density like an ordinary negative. The reverse side of the plate, however, shows the complementary colors, somewhat fainter than the original colors which appear on the film side of the plate.

If the plates were, in reality, negative by transmitted light, it might be possible to obtain by two steps instead of the one employed in ordinary photography, a number of copies from a single negative. The remaining method is to copy the reflected image, and, as the reflected colors are bright, this may not prove impossible. In my experiments certain modifications were introduced with a view of determining several points which are not brought out by the original experiment as reported by Lippmann. It is difficult to obtain a plate which shall be transparent and yet possess any sufficient degree of sensitiveness. The plates I have found most satisfactory hitherto are of collodion on a thin substratum of albumen.

Following is the formula employed:

(1)	Cadmium bromide	25 g.
	Alcohol	280 c.c.
	Hydrochloric acid	5 c.c.
	Of (1)	5 c.c.
	Ether	40 c.c.
	Pyroxyline	2 g.

Sensitize by adding, drop by drop, a solution of silver nitrate, 1 g., in alcohol, 10 c.c., and pour without waiting for the emulsion to ripen.

The film obtained is a pale opalescent blue, almost perfectly transparent, and requires an exposure of twenty minutes or more in direct sunlight to produce images of the green and red. It should be remarked, however, that the image is not latent but appears nearly as strong without the use of a devel-

oper as when development is resorted to. Suitable developers will doubtless reduce the time of exposure.

The plates were exposed against mercury, not, however, to the spectrum, as with Lippmann, but to light transmitted by strips of variously colored glass, one object being to determine whether the ordinary colors of objects, consisting, as they do, of a mixture of rays of several different wave lengths, would be reproduced with the same fidelity as were the pure rays of the spectrum. The composition of the light transmitted by the strips of colored glass employed as determined by the spectroscope is shown in the following table:

Red: All the red with distinct traces of orange and green.
Orange: The entire spectrum reduced in intensity.
Green: A band extending from the middle of the blue to the middle of the red.
Blue: Blue, with bands throughout the green and red.
Purple: Green and red.

The results obtained, though by no means conclusive at all points, seem to indicate: First, that mixed colors may be reproduced with some fair degree of accuracy, though some curious modifications sometimes occur. Thus, a thickening of the film between exposure and final drying, will occasionally change all the colors in the direction of the red end of the spectrum. A shortening of the distance between the thin plates, and a consequent displacement toward the violet, on the other hand, may be produced by allowing the incident light to strike the reflecting surface of mercury, at an angle other than the normal, thus shortening the distance between the maxima which mark the layers of reflecting deposit in the sensitive film. Second, that an exposure sufficiently long to give a clear image of the red is quite certain to obliterate the blue by over-exposure. Third, that an over-exposure may completely reverse the colors, causing the original colors to appear on the reverse, and the complementary on the film side of the plate.

Art. XXXIX.—*New Analyses of Uraninite;* by W. F. Hillebrand.

Since the publication of a former paper on the occurrence of nitrogen in uraninite and on the composition of uraninite in general* no advance has been made toward clearing up the mystery surrounding the composition of that mineral, although

*This Journal, III, xl, p. 384; Bull. U. S. Geol. Survey, No. 78, 1889-1890, p. 43.

considerable work has been done in certain directions, some of which is of sufficient interest to be produced later in a separate publication. In addition several analyses of uraninite have been made, the material being in part from localities hitherto unrepresented by analytical data, and these form the subject of the present paper.

A first glance sufficed to show that the specimens were not fresh and that therefore analysis could throw no light on the ultimate composition of the mineral, but valuable data to be obtained as to the presence or absence of nitrogen and of the rare earths furnished ample excuse for the work.

	I. Llano Co., Texas. *a.* Hillebrand	*b.* Hidden and Mackintosh.	II. Marietta South Carolina.	III. Villeneuve P. Quebec, Canada.	IV. Johanngeorgenstadt, Saxony.
UO_3	44·17	46·75	83·95[5]	41·06	59·30
UO_2	20·89	19·89		34·67	22·33
ThO_2	6·69	7·57	1·65	6·41	
ZrO_2	0·34		0·20	?	
CeO_2	0·34		0·19	·40	none.
La group.	2·36		2·05	1·11	
Y group.	9·46[1]	11·22[4]	6·16[6]	2·57[7]	
CaO	0·32		0·41	·39	1·00
PbO	10·08	10·16	3·58	11·27	6·39
H_2O	1·48	2·54(ign.)	undet.	1·47	3·17
N	0·54		"	0·86	0·02
SiO_2	0·46[2]		0·20	0·19	0·50
Insol.	1·47[3]	1·22		0·13	
Fe_2O_3	0·14	0·58	*tr.*	0·10	0·21
X			*tr.*[8]	0·09[9]	5·03[10]
	98·74	99·93	98·39	100·72	97·95
Sp.G.	8·29	8·01			6·89

[1] At. wght. 111·4. [2] From thorogummite. [3] Mainly fergusonite. [4] At. wght. 124·2. [5] As U_3O_8. [6] Atomic weight 113·6. The oxalates of this group were white, not pink like those in I*a*, but the color of the ignited oxides was the same in both cases and very light. [7] Atomic weight 111·2 approximately. [8] MgO, Na_2O. [9] Bi_2O_3. [10] Includes: Al_2O_3(?) 0·20, Bi_2O_3 0·75, CuO 0·17, MnO 0·09, MgO 0·17, Na_2O 0·31, P_2O_5 0·06, As_2O_5 2·34, V_2O_5, WO_3, MoO_3(?) 0·75, SO_3 0·19=5·03.

No. I*a* is a re-analysis of nivenite from Llano County, Texas, the material for which was kindly given by Mr. W. E. Hidden. It agrees in the main with the original analysis of this variety by Hidden and Mackintosh,* which is reproduced under I*b*, and it confirms the presence of nitrogen, suspected but not proven by them. A small remnant of their original powdered sample gave me 0·52 per cent of nitrogen. In *a* the earths appear in slightly greater total amount than in *b* and they are more subdivided into groups and elements, which accounts fully for the difference between the atomic weights of the metals of the yttrium group of the two analyses. It was rendered certain by a second test that a group of earths whose

* This Journ., III, xxxviii, 1889, p. 481.

sulphates are insoluble in potassium sulphate other than those of Th, Zr, and Ce is present.* A very satisfactory turmeric paper reaction for zirconia was obtained in this analysis as also in that next following, which would go to show that the hypothetical ZrO_2 of several of my earlier analyses was probably in fact zirconia. The cause of the considerable loss shown by the analysis is not known. It may be mentioned that nivenite is more soluble than any uraninite heretofore examined by me, not even excepting cleveite. One hour sufficed for complete decomposition in very dilute sulphuric acid ($1H_2SO_4$ to $6H_2O$) at the temperature of boiling water.

No. II is from a new locality, Marietta, Greenville Co., South Carolina, and the total amount found, a few small fragments, was kindly given by Mr. W. E. Hidden for examination. It was impossible to free the least altered portions from the yellow and orange alteration products with which they were intimately commingled, therefore the analysis represents the composition of a mixture. Unfortunately also the portion in which UO_2 and N were to be estimated was lost, but it was seen that the mineral was very soluble and gave off considerable gas. From the preponderance of the yttrium group over the other rare earths the mineral is to be classed with nivenite and cleveite rather than with those varieties rich in thoria, a a conclusion already foreshadowed by its ready solubility.

No. III is an analysis of uraninite from the Villeneuve mica mine, Township of Villeneuve, Ottawa County, Province of Quebec, Canada. To Mr. G. C. Hoffmann, of the Canadian Geological Survey, who first recognized and reported this occurrence,† I am indebted, for the material analyzed. It was evidently somewhat altered and was accompanied by oxidized alteration products. Hoffmann gives the density of a piece as 9·055. Crystalline form was lacking, but it unquestionably belongs to the crystallized uraninites, being found like most if not all of them in coarse granite (pegmatite).

No. IV represents the composition of a specimen from Johanngeorgenstadt in Saxony, received from Mr. A. Lösch, of St. Petersburg, through Mr. E. A. Schneider of the U. S. Geological Survey. Notwithstanding the altered and crumbling character of the specimen it is proper to publish the analysis, since the only one previously made that has come under my observation, by Pfaff in 1822, is very incomplete. By panning, a very fair article as regards visible impurity was

* It may be here remarked that the subdivision of the earths into the groups indicated by $(La,Di)_2O_3$ and $(Y, Er)_2O_3$ in all my former analyses should not be taken too literally. By the former is meant those earths insoluble in potassium sulphate and by the latter those soluble in that reagent.

† Annual Report Can. Geol. Sur., vol. ii, 1886. Report T, p. 10.

obtained. It is not known wherein the loss is to be sought. Like the great mass of the Bohemian mineral this showed no evidence of ever having been crystallized, and as in that also rare earths are absent, and also nitrogen except for an uncertain trace.

From the analyses of uraninite thus far made it appears that the species may be broadly divided into two groups, the one of which is characterized by the presence of rare earths, the other by their absence. With the former group nitrogen appears to be invariably associated, while in the latter it is present, if at all, only in minute quantity. Besides these chemical differences there is one of another kind, for probably all varieties of the first group occur in more or less well defined crystals, while the members of the second group are generally, if not altogether, massive and free from crystalline form. These differences suggest naturally a dissimilarity of origin and environment. Examination shows that the manner of occurrence and the association of other minerals is different and in such a way as to render an unlike immediate origin probable. All of the rare earth uraninites, with exception of the zirconiferous variety from Black Hawk, Colorado, occur as an apparently original constituent of coarse granites (chiefly pegmatitic), while the others are evidently of secondary formation, as evidenced by their presence in metalliferous veins in more or less intimate association with numerous sulphides of silver, lead, cobalt, nickel, iron, zinc, copper, etc. The Colorado variety occupies an anomalous position as regards the two groups. I prefer to regard it provisionally as a member of the second group, where its mode of occurrence and want of crystalline form as well as small percentage of nitrogen seem to place it, although its zirconia and traces of other earths would admit it to the first.

Attention is called to the above points merely to show that the chemical and physical differences of the two groups may be susceptible of more simple explanation than would appear from the face of the analyses.

Laboratory U. S. Geological Survey, Washinton, D. C., June.

Art. XL.—*The Tertiary Silicified Woods of Eastern Arkansas;* by R. Ellsworth Call.

(Published by permission of the State Geologist of Arkansas.)

The occurrence of silicified wood in the sands and gravels of the Tertiary of the Lower Mississippi Valley has long been known. Aside, however, from the numerous localities mentioned by Hilgard,* nearly all of which are in the state of Mississippi, little attention has been given it. Numerous geologists have spoken of it or incidentally studied it in connection with other investigations, but hitherto no attempt has been made to recognize the species and fix their taxonomic value, if, indeed, they possess any such value. Among those who have investigated the Orange Sands and other Tertiary deposits of the Mississippi Valley and who have added to our information as to the occurrence of these fossils are Hilgard,† Penrose,‡ and Knowlton.§

The last named has made the only microscopic study of these fossils which is on record. Since his investigations are based upon material which, for the most part, was collected by the writer, it is thought that it will be useful to place on record in this form, a more detailed statement of the conditions of the occurrence of the silicified woods, their peculiarities, their structural relations and their stratigraphical position, in the hope that it may eventually prove to be of use in correlating the deposits in which they are found.

These fossil woods occur throughout the area covered by Tertiary sands and gravels in the State of Arkansas. When in large masses they are apparently rarely far removed from beds of Tertiary lignite; if in small masses or in small fragments they occur in the gravels of nearly all the region and in the beds of the streams and brooks of the area covered by the Tertiary. Occasionally whole trunks of trees are found, often partially buried in the sands or deeply imbedded in the gravels which cover the flood plains of the creeks and ravines within the Tertiary area and especially along Crowley's Ridge, from Helena to the Missouri line. Specimens have been obtained from logs or stumps *in situ* and in undisturbed Tertiary beds at the following points: Hope, Hempstead county;

* Agriculture and Geology of Mississippi, 1860, pp. 20, 21, *et seq.*

† Agriculture and Geology of Mississippi, 1860, pp. 20, 21, *et seq.*

‡ First Annual Report of the Geological Survey of Texas, 1889; "A Preliminary Report on the Geology of the Gulf Tertiary of Texas from Red River to the Rio Grande." By R. A. F. Penrose, Jr., pp. 1-101.

§ See Annual Report of the Arkansas Geological Survey for 1889, vol. ii, pp. 249–267, Plates IX–XI.

Camden, Ouachita county; near Red Land, Cleveland county; at Red Bluff, Jefferson county; at Helena, Forrest City, Wittsburg, Wynne, Harrisburg, Jonesboro, Gainesville, Boydsville, and St. Francis in the country traversed by Crowley's Ridge in the eastern part of the State. All of these localities have furnished examples of silicified wood from large logs or stumps in place and always imbedded in Tertiary sands or gravels. It is a remarkable fact that hitherto, in Arkansas, silicified woods have been seen but very rarely in the Tertiary clays. At all the localities mentioned above, except one, the wood is found only in gravels or sands, *in situ*, or in redeposited gravels and sands in the low valleys.

The geological section of the Crowley's Ridge region, to which area this paper especially refers, shows the following sequence, seen in the generalized section in St. Francis county which is characteristic for the southern portion.

Generalized Southern Section on Little Crow Creek.

1. A loess soil, with enough sand to render it decidedly siliceous. This is the surface member and is usually of but little depth.
2. Typical loess, varying in depth from thirty to ninety feet, eroding rapidly, and presenting a characteristic loess topography. This member caps the ridge even at its highest points.
3. A clayey, pebble-bearing, bluish or otherwise dark colored loess clay which forms the base of the typical loess deposits and probably marks the first stage in the loess deposition. This member varies somewhat in different localities, being often quite thin and is even sometimes wanting. The pebbles are most abundant in the lowermost portion.
4. Orange-colored gravels, irregular in thickness, rudely stratified, sometimes well assorted so that only coarse gravels, or *vice versa*, are seen; there are occasional pockets or lenses of sand derived from the underlying member. In rare instances this bed lies directly upon the clays. Silicified coniferous wood often occurs in this member.
5. Party-colored sands, of variable fineness, often quite irregularly stratified, sometimes overlying the pebble bed but usually occurring underneath it. The sand grains are well rounded. There are occasional masses or pockets of red, drab, white, or yellow pipe clay.
6. Blue, black or drab clays, horizontally stratified, with small sometimes large pieces of coniferous lignite. This member constitutes the greater portion of the body of the ridge. Along its margin it is to be seen only in the deepest ravines, or along the St. Francis and such of its small tributaries as flow from the ridge. It is often penetrated in deep wells, as at Forrest City, and underlies the whole region. The lower exposed portion is fossiliferous, the fossils are marine, and Claibornian in age. The clays are therefore Eocene Tertiary.

Slight differences in the section appear in various portions of the Ridge but are not worthy of remark in this connection. The generalized section for the northern portion of the Ridge, made at a point seventy-five miles north of St. Francis county shows the following sequence:

Generalized Northern Section near Gainesville, Greene County.

1. A humus, largely siliceous, or a soil mainly sand. At the highest hilltops this soil contains gravel or may be entirely replaced by waterworn gravel.
2. Gravel bed, commonly removed by erosion.
3. Sands of Tertiary age, false bedded, party-colored, coarse or fine, banded often with drab, red or white pipe clay, or the last may be in pockets or lenses. These sands are generally loose, but in certain localities they have metamorphosed into a very hard, glassy quartzite. The areas of metamorphism are linearly distributed over many square miles but are confined chiefly to the west side of the ridge. Silicified woods are found in this member at many localities, but none has yet been discovered in the metamorphosed portions.
4. Drab, blue and black clays of Eocene Tertiary age, horizontally stratified, occasionally fossiliferous, the fossils being chiefly the leaves of deciduous trees. These clays contain rare beds of lignite of small extent and erratic vertical distribution. Moreover, the clays are commonly gypsiferous and are further characterized by abundant small plates of muscovite in the cleavage planes. Silicified wood was seen at a single locality, on Cache River.

The absence of fossils in nearly all the members of the Arkansas Tertiary renders necessary their distinction upon lithological and structural data. The large masses of silicified wood in the upper members of the series are the only organic forms known above the Eocene clays. If in any way these silicified woods may be genetically connected with the lignite beds a means of correlation will not certainly be had but the fact may sometime possess taxonomic value. Studies made in eastern Arkansas seem to show that all or nearly all of the silicified woods of the Tertiary sands and gravel beds are derived in some manner from the underlying beds of lignite. In many places whole tree trunks, stumps standing in place, or large fragments of silicified wood occur so related to lignite deposits as to show that they are derived therefrom. In the northwestern portion of Greene county, on the west side of Crowley's Ridge, are masses of wood partly in the form of lignite and partly silicified. The lignitized part is buried in Eocene clays; the silicified ends are buried in Eocene Tertiary sands. It would appear that in this case, before the sands

were eroded away, the portion of the trunk which had been buried therein was subjected to the action of waters containing silica in solution and the lignitic matter was replaced by silica.

The silica is, of course, all present as secondary quartz, is often massive but, also, frequently crystallized. Especially is holocrystalline quartz abundant in specimens of wood that were partially decayed when the older lignification process began. In the drusy cavities of such lignite are found large numbers of perfect and rather large quartz crystals. These are often, in some specimens always, characterized by a uniform dark or brownish color which is due to inclusions of limonite.*

Professor F. H. Knowlton, of the U. S. Geological Survey, has studied microscopically both the lignite and silicified woods found in eastern Arkansas. The results of his work may be found in vol. ii of the Arkansas Geological Survey, Reports for 1889. His studies have developed the interesting fact that the woods belong to both dicotyledonous and coniferous types. This occurrence is the first known dicotyledonous wood found in this country in rocks older than Pleistocene and is the first dicotyledonous form determined by internal structure. If, therefore, examinations of both lignites and silicified woods are made and it results that the same form or forms are represented in both, a strong reason exists for genetically connecting the silicified woods with the lignites.

Unfortunately for taxonomic purposes all the forms described by Prof. Knowlton are new, but some otherwise valuable results have been reached. In the first place he finds, among the four new species studied, two forms which are clearly dicotyledonous, and two others distinctly coniferous in relationship. The species are:

Coniferous.	Dicotyledonous.
Cupressinoxylon Arkansanum,	*Laurinoxylon Branneri*,
Cupressinoxylon Calli,	*Laurinoxylon Lesquereuxiana.*

There was also a single additional specimen whose affinities appeared to be dicotyledonous and to belong to *Laurinoxylon;* the condition of the material would not admit of closer determination. The specimens found indicate comparatively few species but these few must have existed in great numbers. One of the most valuable and pertinent facts in this connection is the finding of the dicotyledonous *Laurinoxylon Branneri* in the lignite bed of Bolivar Creek, as lignite, deeply buried in Eocene clays in massive form.

* An especially fine example of this nature was taken from a section in Tertiary sands 13 miles southeast of the town of Camden on the line of the Camden and Alexandria railroad. Of the many thousands of quartz crystals which this specimen exhibits not one has been seen which is free from inclusions of limonite.

Thus far sufficient distributional facts to give a taxonomic value to the fossil woods have not been discovered. Until extensive collections throughout the whole region of the southern Tertiary have been made it will not be possible to use these forms for purposes of differentiation or of correlation. It is believed, however, that since in the Tertiary sands of Arkansas, Louisiana, Texas and Mississippi the same relations of silicified woods to lignites have been observed, it may be possible to coördinate the divisions recognized in those states by geologists and devise a system of nomenclature that will explain the relationships of the various beds to each other, though it cannot be done at present.

During the progress of the study of the region by the writer it became more and more clear that the silicified wood had some intimate relation to the pockets or beds of lignite which are scattered throughout the ridge. It was early noticed that no lignite occurs in the sands or gravels above the clays, and that no detached masses of silicified wood occur entirely in the clays. As the investigation proceeded it became a favorite hypothesis that the silicified wood was transformed lignite, and that careful microscopic study would probably prove the hypothesis to be correct. Professor Knowlton's investigations appear to verify the hypothesis.

The opinion that the silicified wood was, in some way, to be connected with the lignites of the beds underlying the sands was suggested by Hilgard* many years ago. Speaking of the occurrence of fossils in the Orange Sands he says: ". . . . The closest scrutiny I have bestowed on hundreds of extensive exposures, has failed to detect any fossil apparently peculiar to the formation as such. This might seem paradoxical enough to any one acquainted with the frequent occurrence of silicified wood in these strata, but it soon becomes quite obvious to an attentive observer that the regions of the frequent occurrence of this fossil in the Orange Sand are coextensive with those in which fossil wood, either silicified—when imbedded in siliceous sands—or lignitized, occurs in the underlying lignitiferous Cretaceous or Tertiary strata. It is not unusual to find trunks of silicified wood imbedded partly in the unchanged lignitic strata, partly in the Orange Sand; the portion contained in the latter being nearly or wholly deprived of carbon, while the part imbedded in the lignitic material is, if at all silicified, of an ebony tint and often contains pyrites." Again, "I am convinced that the great part, if not all of this fossil wood is derived from the underlying strata and will be represented in their flora."

* This Journal, II, vol. xli, p. 313, 1866.

There can be little question, therefore, that the process of silicification has occurred, in some cases at least, since these masses were torn from the underlying beds by the waters which deposited the sands above the clays.* As ordinarily understood the process is purely a chemical one and perhaps very slow. It consists in the replacement, particle by particle, of the carbon of the lignite by silicic acid, or silicon dioxide. It is by no means essential that the organic matter be unchanged when the process begins. If the belief that this wood represents what was once lignite be a correct one, then the process of silicification can occur in the case of organic matter which has already undergone a partial change.

Where found in clays in a silicified condition, it has probably resulted from the same processes that are seen to obtain in the highly siliceous sands or gravels which overlie them. Though the impervious nature of most clays renders the percolation of of silica-charged waters a matter of great difficulty such percolation certainly occurs in them. The silicified masses of wood are often far too large to have been removed from the clays and deposited in the overlying gravels by an ordinary wave or current action for they sometimes weigh tons. In the form of lignite the same masses could have been transported by currents but since very large pieces have been rarely, if ever, found far from lignite deposits even that proposition has very little weight.

The vertical distribution of the silicified woods of the Arkansas Tertiary is limited by the line of contact between the sands and clays which constitute the Arkansas series. Below this line the silicified wood never occurs, with the single exception above,† so far as observations have yet extended. Above it no

* Dr. R. A. F. Penrose, Jr. (*op cit.*, pp. 24, 26, 50, *et seq.*), has placed on record the numerous occurrences of silicified wood in the Tertiary of Texas; he finds it in both sands and clays. In his description of the Sabine River beds he says: "Silicified wood is of very frequent occurrence in these strata; sometimes occurring as small fragments; and at other times as large trunks of trees. On the Brazos River, in the northern part of Milam County, was seen a trunk one and a half feet in diameter, protruding from a clay bed. Ten feet of it were exposed, while the rest was imbedded in the clay. In many places such fragments are collected in great quantities, but it is especially plentiful in the lower part of the Fayette beds. It is generally dark brown or black inside, and weathers gray or buff color on the outside. Sometimes it occurs partly lignitized and partly silicified. It frequently shows shrinkage cracks which are filled with quartz or chalcedony, and are often lined with quartz crystals."

In this case stratification was but partial or was still in progress and since there is exposed in the face of the bluff a log which was partially lignitized and partly silicified it proves all but conclusively that, even in the Texan Tertiaries, the lignitic precedes the siliceous condition of these woods.

† In this case the stumps are still standing, the roots, also silicified, ramifying in all directions in Eocene blue clays. Less than one hundred feet east, however, the line of contact between the sand beds and the clays was disclosed in a vertical cut in a hillside. This line was at or near the elevation of the stumps. It

lignites have ever been found. The vertical range is therefore limited by the thickness of the sand and gravel bed which is commonly, in Arkansas, between fifty and eighty feet.

There is a marked difference in the vertical range of this fossil in the Tertiary of Arkansas and the Tertiary of California. In the latter State the vertical range is often many hundreds, even several thousands, of feet. Whitney says:* "It will be proper to add to some of the most important facts gathered during the investigation of the gravel deposits in regard to the mode of occurrence of the fossil plants of the Pliocene epoch. The vertical range of these has been alluded to, and it may be more distinctly stated that either fossil wood or leaves have been found at every elevation, from the lowest to the highest, where gravels occur. Even as high as Silver Mountain City, at 7,000 feet of elevation, large masses of fossil wood are found in the volcanic deposits; and in Plumas county the same occurrence has been noted on several of the highest mountains in the region, as Penman's Peak and Clermont, peaks from 7,000 to 8,000 feet high . . . . . Fragments and often large masses of wood are found, both in the gravels and the associated clayey and tufaceous beds. In the gravel they frequently bear the marks of transportation from a distance, as would be expected."

In the California Tertiary the most completely silicified and best preserved specimens of wood occur in connection with deposits of a volcanic character, sometimes a rhyolitic ash.† It is suggested by Whitney that these relationships have something to do with the process of silicification. For that region Whitney believes that not only were the woods silicified after their imbedding in white pulverulent volcanic ash but "the lava itself exhibits signs of having been acted on by silicifying agents after its deposition." That the greater part of the series of beds included in the gravel formation has been thoroughly permeated with waters holding silica in solution and that chemical changes induced thereby are sufficient to explain the phenomena appears quite probable. The relations which the phenomena sustain to the facts of volcanism so abundant in that region are set forth and the conclusion is drawn that that relation explains silicification in these woods. In California it becomes a subordinate problem under volcanism.

The chemical processes which obtained in the case of the Arkansas gravels were not coördinate with those of California,

was clear that, if the stumps did not actually project into the overlying sands, they were but a short distance below and under conditions to favor silicification from waters percolating through the clay to them.

*Auriferous Gravels of the Sierra Nevada, pp. 235, 236. See also this Journal, II, vol. xli, p. 359. 1866.

†Op. cit., pp. 327–329.

for there is no evidence of volcanism or any similar phenomena associated with their silicification. The silica in the eastern locality must be sought in the accompanying sand beds and was probably brought into solution by the action upon it of organic acids.

The study of the Arkansas Tertiary silicified woods appears to justify the following conclusions:

1. The silicified woods of eastern Arkansas are all of Tertiary age.

2. They are derived from the beds of Eocene clays that underlie the sands and gravels in which they commonly occur.

3. They are silicified lignite; the process of silicification has occurred either while they were still in clays or most often after they were removed and buried in the sands or gravels.

4. They possess as yet no taxonomic value in determining the relative ages of the members of the Tertiary series.

Geological Survey, Little Rock, Ark., July 15, 1891.

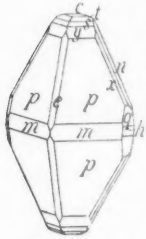
ART. XLI.—*Occurrence of Sulphur, Orpiment and Realgar in the Yellowstone National Park;* by WALTER H. WEED and LOUIS V. PIRSSON.

SULPHUR.

IN the Yellowstone National Park there are besides the well known geyser basins, many small hot spring areas and localities where fumeroles and solfataras are still active. At most of these places deposits of sulphur occur, in and around the vents from which sulphurous vapors issue. At the Highland Hot Springs and at Crater Hills these vents are quite abundant and large deposits of sulphur are found frequently having most beautiful clusters of delicate crystals. The latter locality, from which the specimens herein described were obtained, is a small group of hills whose white and steaming slopes form a prominent feature of the eastern part of Hayden Valley, the open grassy country traversed en route from the Grand Canyon of the Yellowstone to the Lake or the Firehole geysers. The hills, often called Sulphur Mountain, rise about 150 feet above the surrounding level, and are formed of fragmentary material wholly rhyolitic, decomposed and cemented by the vapors that rise at innumerable points through the hills. There are but few springs at this locality; the most prominent and most active is an ever-splashing bowl of green sulphurous waters known as the Chrome Spring. Behind this basin the slopes are light colored, chalky white, rose-pink and dull yellows

being the predominant tints Large masses of rough clinker-like rock lie scattered about the slopes, resting upon small pieces of the same cemented material or upon the smoother slope of white pulverulent silica resulting from the complete decomposition of the rhyolitic material by the acid waters and vapors.

Several parts of the slopes show the dull yellow color of sulphur, such places usually being further marked by many steaming orifices a few inches across. These vents are generally lined with a layer of radially fibrous sulphur, whose surface is thickly set with delicate frost-like clusters of crystals. Many of the vents are partly closed by the sulphur and others completely sealed but filled with hot vapor which is copiously emitted when the roof is broken. No temperatures above 200° F. were obtained from any of the vents. It is in these closed vents that the largest and most beautiful crystal clusters have been found. Upon taking such a specimen from one of these vents it is a deep orange tint, and of course quite hot; as it cools the crystals loosen with a loud and continuous crackling so that a slight jar is sufficient to cause many of the clusters to fall to pieces when cooled. These crystal clusters are of interest as sulphur in the crystal form has been described from but one American locality—Nevada.* In examining a mass of these crystals it is seen that the crystalline mass is of great brittleness, owing largely to the fact that the crystals are generally hollow. Often a mere skeleton of what would otherwise be a good sized crystal is present. One that would be an inch high and proportionately broad and wide consists only of narrow strips preserving the edges of the pyramids on each other: this frame work is then filled with other crystals and parallel growths, also of hollow delicate material. In general the mass is made up of confused crystal aggregates closely united below and toward the top branching into arborescent forms. Often small solid crystals occur attached to the mass. Several of these were selected for measurement. They proved to be of the usual orthorhombic symmetry. The habit is strongly pyramidal. One of them that is typical of the series is shown in the figure. The forms which were identified on this crystal are:



c, 001, *O.*	*e*, 101, 1-$\breve{\imath}$.	*y*, 112, $\frac{1}{2}$.	*x*, 133, 1-$\breve{3}$.
m, 110, *I.*	*n*, 011, 1-$\breve{\imath}$.	*s*, 113, $\frac{1}{3}$.	*q*, 131, 3-$\breve{3}$.
h, 130, *i*-$\breve{3}$.	*p*, 111, 1.	*t*, 115, $\frac{1}{5}$.	

The identification of these forms is shown by the following tables of calculated and measured angles. For

* E. S. Dana, this Journal, xxxii, p. 389, 1886.

the calculated angles the axes of Koksharow* have been taken in which,

$$\breve{a} : \bar{b} : \dot{c} :: 0{\cdot}81309 : 1 : 1{\cdot}90339.$$

Forms.		Calculated.	Measurement.
$p \wedge p$	$111 \wedge \bar{1}11$	94° 52′	94° 51′, 94° 41′, 94° 40′
$p \wedge p$	$111 \wedge 11\bar{1}$	36 40½	36 43, 36 44½
$p \wedge m$	$111 \wedge 110$	18 20½	18 20½, 18 22½
$p \wedge e$	$111 \wedge 101$	36 47	36 45, 36 50
$p \wedge n$	$111 \wedge 011$	47 26	47 35, 47 15
$p \wedge x$	$111 \wedge 133$	27 29	27 25, 27 27, 27 30
$p \wedge q$	$111 \wedge 131$	29 10½	29 08, 29 17
$p \wedge y$	$111 \wedge 112$	15 11½	15 13½
$p \wedge s$	$111 \wedge 113$	26 29¾	26 28½, 26 30½
$p \wedge t$	$111 \wedge 115$	40 33½	40 34
$p \wedge c$	$111 \wedge 001$	71 39¾	71 41½

In general the planes, even though minute, gave fair reflections owing to the brilliancy of their surfaces. The only exception to this was the plane $\breve{i}$-$\breve{3}$ 130, from which no satisfactory reflections could be obtained. It is easily identified however since it lies in the zones $110 \wedge 1\bar{1}0$ and $001 \wedge 131$.

Though no tests were made the material is apparently of great purity. It is very homogeneous and is of a delicate sulphur-yellow.

Orpiment and Realgar.

The presence of arsenic in the hot spring waters of the Yellowstone Park, and the deposition of the hydrous arseniate of iron, scorodite, by them, has already been noticed in this Journal.* While studying the hydro-thermal phenomena of the region for the U. S. Geological Survey, under the direction of Mr. Arnold Hague, a careful search for deposits of the arsenical sulphides was rewarded by the discovery of realgar and orpiment, at the Norris Geyser Basin. This locality, though possessing few geysers worthy of comparison with those of the Firehole basins, is peculiarly interesting by reason of the newness of its geysers and the great variety of its chemical deposits. It covers an area of some six square miles situated amid the forests of the great rhyolite plateau of the Park whose gradual slopes rise on every side. The area of present activity is included between a loop of the Gibbon river and two spurs of Gibbon Hill, an eminence of rhyolite that rises above the general level of the country to the south. The multitude of

* Min. Russl., vi. p. 368, 1874.

* A. Hague, this Journal, vol. xxxiv, Sept., 1887.

vividly colored pools and equally bright tinted waterways, the white sinter flats, and the creamy rose and yellow shades of the decomposed rhyolite, the whole surrounded by a setting of dark green pines, presents a strange picture not easily forgotten.

The specimens of realgar and orpiment come from the western part of this basin, between the 100 spring plain and the Gibbon river. The deposits of siliceous sinter so abundant elsewhere in the basin are here quite scanty and form a thin coating upon rock composed of small angular fragments of pearlite, obsidian, and other forms of rhyolite—generally more or less decomposed and mixed with quartz grains, the whole compactly cemented by silica deposited by the hot spring waters. Several small outflows of clear and hot acid water issue from this cement rock, their united overflow forming a small stream which flows through a shallow gutter in the rock and joins the Gibbon river a few hundred yards beyond. Near the vents the channels are lined with an incoherent deposit of milky sulphur which frequently coats and obscures a growth of *algæ*. The gray surface of the rock shows no trace of the brilliantly colored arsenical sulphides, and it is only upon breaking this rock about the vents and prying up the plates at the margins of the channels that the realgar and orpiment are noticed. Plates of rock thus obtained show a brilliant red and yellow surface of the mixed sulphides and large pieces of rock from about the vents are penetrated and filled with deposits of the yellow orpiments, the dark red realgar, and the mixture of the two. Many of the specimens show layers of waxy dark red translucent realgar an eighth of an inch thick, covered by incoherent amorphous orpiment and alternating layers often occur. The orpiment generally possesses a tangled filamentous structure upon the surfaces of the plates as if deposited upon algæ threads, and where the surface of the plate is covered with realgar as is frequently the case, it too possesses this curious form, the mineral being in stalagmitic aggregates with a general fibrous matted structure.

In the channels the rocks show no surface coloring from the deposition of the sulphides but many small pebble-like masses occur, lying in the bottom of the stream, which consist almost entirely of dark red translucent realgar. This appears to be the most promising material collected for mineralogical examination, but unfortunately none of the specimens proved to contain any crystals which could be measured and identified under the microscope it proved to be in rounded stalagmitic growths consisting of a confused crystalline aggregate. Such light reflecting surfaces as were seen proved to be small cleavage planes. In the closed tube the substance melts and then forms

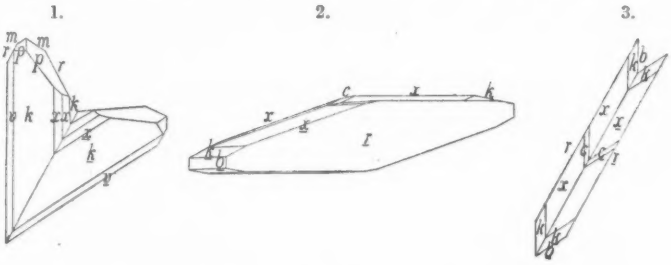
a reddish translucent sublimate. In the open tube with a good current of air volatilizes and deposits in the upper part small glittering octahedrons, which under the microscope in polarized light proved isometric (As_2O_3). Before the blowpipe on charcoal gives characteristic odors for sulphur and arsenic. Fused with carbonate of soda gives the reactions on dissolving for sulphur and arsenic.

The association of the realgar and orpiment is such that no definite statement can be made as to which forms first, but realgar is certainly the last formed upon many of the specimens. Whether it is formed through a conversion of the orpiment or as a separate deposition is uncertain, but the specimens seem to indicate that the latter is the case. Siliceous sinter is the only other mineral occurring with these arsenical sulphides.

ART. XLII.—*Mineralogical Notes;* by L. V. PIRSSON.

1. *Cerussite.*—Some specimens of cerussite, obtained through Messrs. English & Co., of New York, from the Red Cloud Mine in Yuma Co., Arizona, contain twin crystals in which the twinning plane is the uncommon form $i\text{-}\breve{3}$, 130. Since, moreover, they show some unusual developments in their crystal form, it has been thought that a description of them would be of interest. The specimens are in the cabinet of Prof. George J. Brush.

The greater number of those observed have the form shown in fig. 1, which presents them in a basal projection. This



gives a much better idea of these crystals, shaped like arrowheads, than an orthographic projection. They are of various sizes up to half an inch in length, the largest observed. They

resemble the example of this method of twinning given by Koksharow* in the development of the brachydomes. The figure shows them in ideal symmetry; they are generally attached by the barb-shaped end; sometimes one barb or individual is free with the faces developed as in the figure; in other forms both individuals are attached and the barb-like part is wanting. They occur on the specimen seen, with cerargyrite and wulfenite. The forms observed on these crystals are:

r, *i*-3̆, 130; *k*, 1-ɣ̆, 011; *v*, 3-ɣ̆, 031; *x*, ½-ɣ̆, 012; *m*, I, 110; *p*. 1, 111.

Also the pinacoids *i*-ī, 100 and *i*-ɣ̆, 010, the pyramid ½, 112 and the brachy-diagonal pyramid 2-2̆, 121 have been identified in zones on the reflecting goniometer and measured with some accuracy, but they are too minutely developed to give any character to the crystals and are hence omitted in the figures. The crystals are well suited for measurement, the faces generally giving good reflections of the signal.

Fig. 2 shows a crystal from the same place with a different habit, the large ½ brachydome *x* and great development of the brachy-prism *r* having resulted in a long spindle-shape form. Fig. 3 shows the same individual in basal projection. It occurred, attached at the end with the re-entrant angle, which in consequence was somewhat broken. Otherwise the crystal is quite perfect and in size about an inch long. The zone of brachydomes is somewhat striated, causing a rounding off toward the point. The signals of the prominent faces are, however, very distinct and give good measurements. On this crystal the forms observed were:

b, *i*-ɣ̆, 010; *c*, *O*, 001; *r*, *i*-3̆, 130; *k*, 1-ɣ̆, 011; *x*, ½-ɣ̆, 012.

The following table shows the identification of the forms by calculated and measured (supplementary) angles.

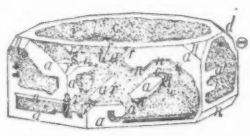
		Calculated.	Measured.
$k \wedge p$	011 ∧ 111	43° 50′ 40″	43° 51′
$m \wedge p$	110 ∧ 111	35 46 20	35 45, 35 50, 35 49
$k \wedge r$	011 ∧ 130	59 03 10	59 00
$p \wedge p$	111 ∧ 111	49 59 30	49 58
$m \wedge r$	110 ∧ 130	29 57 30	30 00, 30 01
$p \wedge r$	111 ∧ 130	45 19 55	45 16, 45 22
$v \wedge v$	031 ∧ 031	49 30	49 27
$k \wedge x$	011 ∧ 012	15 59 30	16 00, 16 04
$k \wedge k$	011 ∧ 011	108 16	108 12, 108 14
$r \wedge x$	130 ∧ 012	72 38 30	72 35
$c \wedge x$	001 ∧ 012	19 52 30	19 48
$r \wedge b$	130 ∧ 010	22 39 30	28 37, 28 31
$k \wedge b$	011 ∧ 010	54 08	54 17
	001 ∧ 112	34 46	34 54
	121 ∧ 121	85 59	86 00

* Min. Russl., vi, pp. 106, 1870. Also Atlas Taf. lxxx, figs. 20 and 20 bis.

2. *Hematite and Cassiterite.*—Interesting specimens of hematite and cassiterite intimately associated and crystallized have been forwarded by Prof. F. A. Genth for crystallographic examination. The place from which they come is Mina del Diablo, Durango, Mexico. Among them a number of undoubted pseudomorphs of cassiterite after hematite were observed. They are too small and lusterless for the forms to be determined, but the whole grouping is precisely the same as that of hematite in the familiar "Eisenrose" habit, consisting of radiating plates. Often the central portion of these plates consists of a piece of hematite, the outer surrounding part of tin oxide. There were also seen pseudomorphs of cassiterite after some octahedral mineral, probably magnetite.

These occurrences of cassiterite and hematite have already been described by Genth and vom Rath,* but in these specimens lately examined an additional point of interest was noted. This is the presence of cellular crystals of hematite filled with cassiterite. One of these is shown in fig. 4. The forms present on this crystal are

4.



c, 0001, O; *a*, $11\bar{2}0$, *i*-2; *r*, $10\bar{1}1$, R; *η*, $01\bar{1}1$, -1; *s*, $02\bar{2}1$, -2; *n*, $22\bar{4}3$, $\frac{4}{3}$-2; *d*, $10\bar{1}2$, $\frac{1}{2}$; Θ, $20\bar{2}1$, 2.

Those chiefly developed are the prisms and the basal pinacoids which give the crystals its habit. In reality these faces are present to a considerable degree only along the edges, the remaining parts being sunken and filled with a roughened surface of cassiterite which runs on through the crystal. The polish and luster of as much of the face as is present is, however, very fine and brilliant.

A thin section of this individual was prepared parallel to the unit prism to ascertain if the cassiterite had here also any definite orientation in regard to the hematite. None was observed. The two minerals, both appearing fresh and unaltered, were present in irregularly mingled masses. The cassiterite was formed of an intimate crystal aggregation as shown by its slight but uniform action on polarized light.

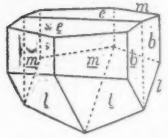
From these facts it would seem as if the two minerals had been formed simultaneously and the hematite having a greater tendency to crystallize than the cassiterite had assumed its crystal boundaries without regard to the latter.

3. *Gypsum.*—The crystals which are illustrated in fig. 5 are from Girgenti, in Sicily, and are now in the cabinet of Prof. Geo. J. Brush. They are twinned according to the usual method,

* Proceedings Am. Phil. Soc., 1887, xxiv, 23.

the twinning axis a normal to 100 and the following simple forms are present, *m*, *I*, 110; *b*, *i-i*, 010; *l*, -1, 111; and *e*, $\frac{1}{3}$-$\bar{1}$, $\bar{1}03$. Since the orthodome $\frac{1}{3}$-$\bar{1}$, lacks only about two degrees of forming a right angle with the orthopinacoid, the two domes in twin position practically present the appearance of a basal plane and the whole crystal that of hemimorphic orthorhombic rather than of monoclinic symmetry. This pseudo-basal plane is rough and oscillatory and the very slight salient angle cannot be detected. The crystals are of good size and very symmetrical except at the end where the twin pyramids are; they are attached by this point and are as a consequence broken and disturbed at this place.

5.



4. *Pennine.*—The crystal form and optical properties of the violet chrome pennine or kämmererite from Texas, Penn., were originally described by Cooke* from specimens from the cabinet of Prof. Brush. At the request of Prof. E. S. Dana I have recently studied the suite of specimens in Prof. Brush's collection from this locality and thanks to the present perfection of apparatus for crystallographic investigation, I have been able to make out several forms observed by Prof. Cooke but which he was not then able to determine. The forms observed on these crystals are as follows:

O, 0001; R, $10\bar{1}1$; *y*, $\frac{2}{3}$, $20\bar{2}5$; *φ*, $\frac{4}{13}$, $4{\cdot}0{\cdot}\bar{4}{\cdot}13$; *z*, $\frac{1}{3}$, $10\bar{1}3$; *ρ*, $\frac{1}{2}$-2, $11\bar{2}4$ *χ*, 1-2, $11\bar{2}2$.

The last three are new. The habit is shown in figs. 6 and 7. Fig. 6 is very similar to that given by Cooke, omitting the pyramids of the second order. As observed by him the crystals are generally twins. The planes forming the re-entrant angle are nearly always more or less striated, moreover this re-entrant angle is, so far as observed, invariably formed by the unit rhombohedron R ($10\bar{1}1$). Fig. 7 shows a case where there was practically no striation and the angle could be measured. The presence of pyramids of the second order is a noteworthy characteristic, on no crystal out of a large number was it ever wanting. With one or two exceptions, on very small crystals, they were invariably striated as shown in fig. 7. These striations all lie in one zone, and this having been determined, it was possible to measure from the base along this zone, the reflections of various pyramids which stood out in the band of light connecting them.

In this way the presence of $\frac{1}{3}$-2 ($11\bar{2}6$), $\frac{4}{5}$-2 ($22\bar{4}5$), $\frac{9}{16}$-2 ($9{\cdot}9{\cdot}\bar{1}8{\cdot}20$) and $\frac{7}{4}$-2 ($7{\cdot}7{\cdot}\bar{1}4{\cdot}8$) was determined by moderately

* This Journal, vol. xliv, pp. 201, 1867.

good measurements, some of which were repeated on several crystals.

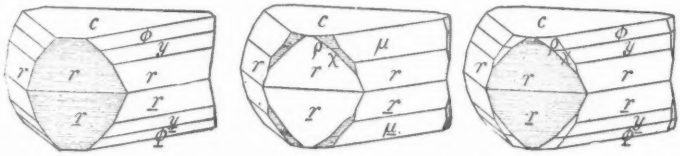
The following table shows the identification of the forms by calculated and measured angles. For the calculated the elements of Cooke are taken, in which

$$a : c = 1 : 3{\cdot}4951. \quad c \wedge \mathrm{R}\ (0001 \wedge 10\bar{1}1) = 76^\circ\ 05'.$$

	Forms.	Calc.	Meas.
$c \wedge r$	$0001 \wedge 10\bar{1}\bar{1}$	103° 55′	104°
$c \wedge \phi$	$0001 \wedge 4{\cdot}0{\cdot}\bar{4}{\cdot}13$	51 09	51° 06′
$c \wedge y$	$0001 \wedge 20\bar{2}5$	58 13	58 05
$c \wedge z$	$0001 \wedge 10\bar{1}3$	53 22½	53 48
$c \wedge \rho$	$0001 \wedge 11\bar{2}4$	60 13½	60 35
$z \wedge \rho$	$10\bar{1}3 \wedge 11\bar{2}4$	25 54	25 22
$c \wedge \chi$	$0001 \wedge 11\bar{2}2$	74 05	74 10

The form 1-2 ($11\bar{2}2$) was also identified by the fact that it lies in the zone between $\frac{1}{3}$ ($10\bar{1}3$) and r, R, ($10\bar{1}\bar{1}$).

6. 7. 8.


c
φ
y
r
r
r

Art. XLIII.—*Peridotite Dikes in the Portage Sandstones near Ithaca, N. Y.;* by J. F. Kemp.

In the valuable paper on the peridotite* at Syracuse, N. Y. which appeared in this journal in August, 1887, the following statement is made and it doubtless expresses a very widespread and general impression. "This rock is interesting as being the only known instance of igneous intrusion in the unaltered and undisturbed Palæozoic strata of New York" (p. 144). Since the writer's first residence in Ithaca (1886), the occurrence of trap dikes in the vicinity has been a subject of frequent discussion in the geological laboratory of Cornell University. Conversations with alumni who were students under the instruction of Professor C. F. Hartt (1868–1878), revealed the fact that he made frequent mention of them and created the impression that they were well recognized phenomena in two of the neighboring gorges. They do not appear to have become a matter of record except in two cases. Professor O. A. Derby (now in Brazil) in a short paper in the Cornell Review (which was the student publication of that date), vol. i, p. 70, 1874, entitled "Hints to Geological Students," mentions a number of localities involving in all four dikes. Three of these are in Cascadilla Creek on the confines of the university and the fourth, said to be the best for study, is in Six-Mile Creek, two or three miles distant. Professor F. W. Simonds (now of Texas) published in 1877, a short article in the American Naturalist (vol. xi, p. 49) on the Geology of Ithaca, N. Y., and vicinity. The Six Mile Creek dike is again mentioned and described as filling a crack in the sides of the gorge but as pinching out before it reached the surface. Long before this, however, in 1842, in the Report on the 3rd District, N. Y. State Survey, p. 169, Vanuxem recorded four narrow dikes in the Genesee slate near Ludlowville, which is ten miles north of Ithaca. The locality has been recently visited by the writer but only the two dikes near the upper falls of Vanuxem could be found. They are each about an inch wide and only show over a short space as they disappear above and below. They were inaccessible and from the distance of a few feet their igneous nature was not conclusively shown. The other two could not be found. Vanuxem also mentions another dike (l. c. pp. 207–208) at Manheim Bridge east of Little Falls, N. Y., more than one hundred miles

*G. H. Williams: The Serpentine (Peridotite) occurring in the Onondaga Salt Group at Syracuse, N. Y., this Journal, August, 1887, p. 144. See also Proc. Geol. Soc. Amer., vol. i, pp. 533, 534.

northeast of Ithaca and seventy-five miles from Syracuse, but what its character is or whether it is indeed igneous is unknown to the writer.

The dike in Six Mile Creek near Ithaca was re-located in 1887, and slides were at once prepared. It proved to be a thin mass 1¼ to 2 inches wide and fills one of the numerous, parallel, north and south joints which are extremely abundant in the shaly sandstones of the region. It crosses the stream like a narrow ribbon and pinches out a few feet above the surface of the water. It has a light brown or drab color with darker spots scattered through and is provided with numerous scales of a reddish mica. It effervesced and in the slides showed a mass of alteration products with very strong suggestions of an eruptive structure, but as the material was so decomposed it was decided to be too meagre, to deserve mention. It was subsequently submitted to Messrs. G. H. Williams, Diller and Derby and the last two were strongly of the opinion that it was igneous and suggested blasting. Later discoveries make this procedure hardly necessary and prove the specimen to be undoubtedly an eruptive rock in advanced decomposition.

During a visit from Professor Derby, the past autumn, the subject of dikes was again brought up and the probable location of one in Cascadilla Creek was indicated. The point is under the discharge raceway of the reservoir forming Willow pond. just east of the entrance to the Cornell Campus. In a recent drouth it became accessible. The dike is about three feet in width and strikes north and south right across the course of the creek. It is in a recess formed by its weathering and a corresponding recess appears on the opposite side, filled however with dirt. It is covered with sand in the creek.

The rock itself is very dark green to black. Its surface is mottled by black protuberances which look very much as if they were pebbles. But they readily crumble under the fingers to a black dirt. The fresher portions have a porphyritic aspect and suggest a peridotite at once, and this is verified by the slides. In the sections the rock is seen to be highly altered. The black masses prove to be the remains of large olivine and enstatite or bronzite crystals.

The latter show very generally the striated appearance so characteristic of these pyroxenes but the silicate itself has changed to serpentine and carbonates. The crystals are 3–5^{mm} in diameter. The recognizable olivine is in smaller crystals than the pyroxene as a general thing, but appears in no inconsiderable amount. It is very probable that the larger, unstriated alteration masses were also olivine. The characteristic reddish biotite of the peridotites is distributed through the

rock, and is still quite fresh. The crystals run about 0·2–0·3^{mm} long. Their distribution indicates at times an excellent flow structure. Magnetite is abundant both in irregular grains and rude crystals. A small amount of a reddish brown mineral, of high index but not entirely isotropic, is also present. It is probably perofskite. The groundmass consists in large part of numerous small acicular crystals of highly inclined extinction which are augite. The groundmass seems originally to have been glassy. An analysis which was kindly made in the chemical laboratory at Cornell by Mr. W. H. Morrison, graduate student in chemistry yielded the following results.

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	Loss	Total.
2/2	37·44	11·92	28·60	5·45	1·97	1·02	0·97	12·67	=100·04

The analysis shows at once the advanced stage of the decomposition and yet indicates a very basic rock. Qualitative tests failed to show chromium.

The rock resembles very closely the Syracuse serpentine described by Dr. G. H. Williams in its general macroscopic appearance and in many of its microscopic characters. The large phenocrysts are the same but the olivine is less fresh than at Syracuse. The reddish mica is present in both. It has also been compared with the peridotite from Elliott Co., Ky.,* and that of Pike Co., Ark.,† and evidently belongs to the same family of rocks but as might be expected it resembles the Syracuse rock most closely.

The occurrence is interesting because it shows the further distribution of igneous rocks in a region supposed to be free from them. Ithaca is some seventy-five or eighty miles south of Syracuse and much higher in the geological scale. The local rocks are shaly sandstones of the Portage stage and are extensively seamed by a series of north and south joints and another series, of west-northwest strike. The dikes in all cases follow the northerly series. It is not improbable that they belong to the same eruptive outbreak that found a larger manifestation at Syracuse. If so the intrusion is put at a date later than the Upper Devonian, but beyond this no further determination can be made with the data at hand.

Geological Laboratory, Columbia College, New York City.

*J. S. Diller: The Peridotite of Elliott Co., Ky. Science, Jan. 23, 1885, p. 65. Bulletin No. 38, U. S. G. S., 1887.

† Branner and Brackett: Peridotite of Pike Co., Ark. This Journal, July, 1889, p. 50.

ART. XLIV.—*A New Locality for Meteoric Iron with a Preliminary Notice of the Discovery of Diamonds in the Iron;** by A. E. FOOTE. With Plates XIV, XV.

Historical sketch of the discovery.—In the latter part of March, 1891, the mining firm of N. B. Booth & Co., of Albuquerque, New Mexico, received a letter from a prospector in Arizona informing them he had found a vein of metallic iron near Cañon Diablo, sending them at the same time a piece with the request for an assay. Sometime in April this piece was examined by a Colorado assayer who reported "76·8 per cent of iron, 1·8 per cent lead, ½ oz. silver, and a trace of gold. From its appearance we should take it to be a furnace product."†

This result was naturally not satisfactory to the mining firm and a mass weighing forty pounds was broken into several fragments with a trip hammer. One of these was sent to the President of the Santa Fe Railroad, and another to Gen. Williamson, the land commissioner of the Atlantic and Pacific Railroad Co., in Chicago. Gen. Williamson consulted me as to the probable value of the so-called mine of "pure metallic iron," stating on the authority of the prospector that the vein had been traced for a distance of about two miles, that it was forty yards wide in places, finally disappearing into a mountain and that a car load could be taken from the surface and shipped with but little trouble.

A glance at the peculiar pitted appearance of the surface and the remarkable crystalline structure of the fractured portion convinced me that the fragment was part of a meteoric mass, and that the stories of the immense quantity were such as usually accompany the discovery of so-called native iron mines, or even meteoric stones. As soon as possible, in June, I made a visit to the locality and found that the quantity had, as usual, been greatly exaggerated.

There were some remarkable mineralogical and geological features which, together with the character of the iron itself, would allow of a good deal of self deception in a man who wanted to sell a mine.

Description of Locality.—Nearly all of the small fragments were found at a point about ten miles southeast from Cañon

*Read before the American Association for the Advancement of Science, August 20th, 1891.

†This assay was of such a remarkable character that I took the trouble to stop at the city where it was made and ask how such extraordinary results were obtained. I was informed that the lead, silver and gold were probably the results of the materials used in making the assay.

Diablo near the base of a nearly circular elevation which is known locally as "Crater Mountain." I believe this is the same as Sunset Knoll figured on the topographical sheets of the U. S. Geological Survey. This is 185 miles (297·72 kilometers), due north from Tucson and about 250 miles (402·34 kilometers) west of Albuquerque.

The elevation, according to the survey, rises 432 feet (131·67 meters) above the plain. Its center is occupied by a cavity nearly three quarters of a mile (1·2 kilometers) in diameter, the sides of which are so steep that animals that have descended into it have been unable to escape and have left their bleached bones at the bottom. The bottom seemed to be from fifty to one hundred feet (15·24 to 30·48 kilometers) below the surrounding plain. The rocks which form the rim of the so-called "crater" are sandstones and limestones and are uplifted on all sides at an almost uniform angle of from thirty-five to forty degrees. A careful search, however, failed to reveal any lava, obsidian or other volcanic products. I am therefore unable to explain the cause of this remarkable geological phenomenon. I also regret that a severe gallop across the plain had put my photographic apparatus out of order so that the plates I made were of no value.

About two miles (3·22 kilometers) from the point at the base of the "crater" in a nearly southeasterly direction, and almost exactly in a line with the longest dimensions of the area over which the fragments were found, two large masses were discovered within about eighty feet (24·38 meters) of each other. The area over which the small masses were scattered was about one-third of a mile (0·53 kilometer) in length and one hundred and twenty feet (36·57 meters) in its widest part. The longer dimension extended northwest and southeast.

Description of the specimens.—The largest mass discovered weighs 201 pounds (91·171 kilos,) and as the photograph shows, Plate XIV, has a somewhat flattened rectangular shape showing extraordinarily deep and large pits, three of which pass entirely through the iron. The most remarkable example of such perforation is the Signet Iron from near Tucson, Arizona, now in the National Museum and figured in Prof. F. W. Clarke's Catalogue.*

One other large mass was found weighing 154 pounds (69·853 kilos.) This is also deeply pitted. A mass weighing approximately 40 pounds (18·144 kilos) was broken in pieces with a trip hammer and it was in cutting one of the fragments of this mass that diamonds were discovered. Plate XV.

* The Signet Iron was discovered about 30 miles (48·28 kilometers) from Tucson. Dr. Geo. H. Horn states that 25 years ago he was told by the Spaniards that plenty of iron could be found on a range of hills extending northwest and southeast half way between Albuquerque and Tucson.

Besides these masses of considerable size a careful search made by myself with the assistance of five men was rewarded by the discovery of 108 smaller masses. Twenty-three others were also discovered making a total of 131 small masses ranging in weight from $\frac{1}{16}$ of an oz. (1·79 grm.) to 6 lbs. 10 oz. (3·006 kilos.)* A brownish white slightly botryoidal coating found on a number of the meteorites, is probably aragonite.

A thorough examination of many miles of the plain proved that the car load of iron existed only in imagination. Accompanying the pieces found at the base of the "crater" were oxidized and sulphuretted fragments which a preliminary examination has shown are undoubtedly of meteoric origin. About 200 pounds (90·718 kilos) of these were secured, from minute fragments up to 3 pounds 14 oz. or (1·757 kilos.) These fragments are mostly quite angular in character, and a very few show a greenish stain, resulting probably from the oxidation of the nickel. This oxidized material is identical in appearance with an incrustation which covers some of the iron masses and partially fills some of the pits.

Composition.—After obtaining the meteorite I was unable to return to Philadelphia for sometime, and, therefore, sent a fragment of the 40 pound mass (18·144 kilos) to Prof. G. A. Koenig for examination. Prof. Koenig was compelled to leave town before this examination was completed. I take the following, therefore, from his letters to me and from an account furnished the daily *Public Ledger* by Dr. E. J. Nolan, Secretary of the Academy of Sciences, of a preliminary notice made by Prof. Koenig, June 23rd, before the Academy of Natural Sciences of Philadelphia. In this account he says:

"In cutting the meteoric iron for study it had been found of a extraordinary hardness, the section taking a day and a half, and a number of chisels having been destroyed in the process. When the mass, which on the exterior was not distinguished from other pieces of meteoric iron, was divided, it was found that the cutting apparatus had fortunately gone through a cavity. In the attempt to polish the surface so as to bring out the characteristic Widmannstättian figures, Dr. Koenig received word that the emery wheel in use had been ruined.

On examination, he then found that the exposed cavities contained diamonds which cut through polished corundum as easily as a knife will cut through gypsum. The diamonds exposed were small, black, and, of course, of but little com-

* Oct. 18th.—During September I received three additional large masses weighing respectively 632, 506 and 145 pounds (or 286·678, 229·516 and 65·771 kilos.) The two latter were each perforated with three holes. A number of smaller masses up to 7 pounds, (3·175 kilos.) were discovered by digging. The three large masses and one of 23 pounds, (10·432 kilos) were covered with grass and earth.—A. E. F.

mercial value, but, mineralogically, they are of the greatest interest, the presence of such in meteorites having been unknown until 1887, when two Russian mineralogists discovered traces of diamond in a meteoric mixture of olivine and bronzite. Granules of amorphous carbon were also found in the cavity, and a small quantity of this treated with acid had revealed a minute white diamond of one-half a millimeter, or about $\frac{1}{50}$ of an inch in diameter. In manipulation, unfortunately, this specimen was lost, but others will doubtless be obtained in the course of investigation. The minerals, troilite and daubréelite, were also found in the cavities. The proportion of nickel in the general mass is three per cent, and the speaker was not as yet able to account for the extraordinary hardness apart from the presence of the diamonds in the cavities."

Prof. Koenig in a letter to me gives the following points as definitely known.

"(1.) *Diamonds*, black and white established by hardness and indifference to chemical agents. (2.) *Carbon* in the form of a pulverulent iron carbide occurring in the same cavity with the diamonds. The precise nature of this carbide, whether containing hydrogen and nitrogen is not ascertained except in so far that after extracting all iron by nitro-hydrochloric acid, the black residue goes into solution with deep brown color upon treating it with potassium or sodium hydrate. From this solution acids do not precipitate anything. (3.) *Sulphur* is not contained in the tough malleable portion of the meteorite but in the pulverulent portion. (4.) *Phosphorus* is contained in the latter, and not in the former. (5.) *Nickel* and *Cobalt* in the proportion of 2:1 are contained in both parts nearly equally. (7.) *Silicon* is only present in the pulverulent portion. (8.) The Widmannstättian figures are not regular. (9.) The iron is associated with a black hydroxide containing Fe, Ni, Co, P, in the ratio of the metallic part and therefore presumably derived by a process of oxidation and hydration of the latter."

Conclusions.—As this meteoric iron contains only 3 per cent of nickel while that from the Santa Catarina Mountains, 30 miles (48·28 kilometers) southeast of Tucson and 215 miles (346 kilometers) from this locality, contains from 8 per cent to 9 per cent, according to the analysis of Brush and Smith, they are quite distinct although somewhat alike in external appearance. They also somewhat resemble the Glorietta meteoric irons from about 300 miles (482·8 kilometers) to the east northeast, in New Mexico. These contain 11·15 per cent of nickel.

The most interesting feature is the discovery for the first time of diamonds in meteoric iron.* This might have been predicted from the fact that all the constituents of meteoric iron have been found in meteoric stones, and *vice versa*, although in different proportions.

The incrustation of what is probably aragonite shown by some of the masses has rarely been noticed (I find two records by J. Lawrence Smith which he states to be unique, and both of these were from regions south of this one). The incrustation is especially interesting as showing that the meteoric irons must have been imbedded a long time, as the formation of aragonite would be exceedingly slow in this dry climate.

The remarkable quantity of oxidized black fragmental material that was found at those points, where the greatest number of small fragments of meteoric iron were found, would seem to indicate that an extraordinarily large mass of probably 500 or 600 pounds (226·796 or 272·156 kilos) had become oxidized while passing through the air and was so weakened in its internal structure that it had burst into pieces not long before reaching the earth.

ART. XLV.—*The South Trap Range of the Keweenawan Series;* by M. E. WADSWORTH, State Geologist of Michigan.

IN a former communication published in the August number of this Journal, it was shown that the eastern or supposed Potsdam sandstone, east of the copper-bearing rocks, underlies, in an apparently conformable synclinal fold, a limestone of Trenton or of some adjacent Lower Silurian formation. It was then suggested that the contorted state of the sandstone might have some weight in deciding the relative age of the eastern sandstone and the adjacent copper-bearing rocks.

In endeavoring to contribute something to the solution of the relation of these two series of rocks, a party under the charge of Mr. A. E. Seaman of the Michigan Geological Survey was directed to go to "Silver Mountain," and thence to study the "South Trap Range," in order to ascertain, if possible, the exact relations of the lava flows of that range and the eastern sandstone. Part of this work has been done, and,

* Attention may be called to the discovery by Haidinger (1846) of cubic crystals of a graphitic carbon in the Arva meteoric iron, and also of somewhat similar crystals from the Youngdegin, W. Australia iron, described by Fletcher (1887) under the name of cliftonite. Both have been regarded as pseudomorphs after diamond.

although far from being as decisive as could be wished, yet the observations would appear to be of considerable interest and importance.

"Silver Mt." (Sec. 1, T. 49, R. 36 W.) was found to be composed of interbedded lava flows, of which at least ten flows were made out with more or less certainty. These flows dip to the northwest at an angle of from ten to sixteen degrees. No sandstone was found nearer than two miles. This has a slight dip to the northwest. On Sec. 29, T. 47, R. 37 W., a series of melaphyr flows were observed dipping at a low angle to the north or a little west of north. The angle of their greatest inclination being from 15° to 20°.

These flows are interbedded with sandstone which holds fragments of the melaphyr. A felsite dike also cuts through the beds.

Similar lava beds are found on Sec. 25, T. 47, R. 38 W., and Sec. 30, T. 47, R. 37 W., which lie at a low angle, 9° to 16° north or a little west of north; while on Sec. 1, T. 46, R. 39, the flows dip from 9° to 20°, the principal dip being to the north at an angle of 14°. Outcrops of the same old basaltic rocks occur on Sec. 35, T. 47, R. 38 W. and Sec. 8, T. 46, R. 39 W., which show a very low inclination.

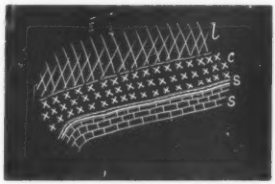
The most important observations were made in Secs. 11, 13 and 14, T. 46, R. 41 W., where the sandstone was found overlaid by some of the lava flows. The sandstone is found in contact with schists presumably of the Archæan or Azoic Age. The base of the sandstone is of a conglomeritic character composed of rolled pebbles of quartz cemented by an argillaceous matrix formed from the debris of the underlying steeply inclined and contorted schists. This sandstone dips at a low angle of from 12° to 14° northerly, its strike being S. 60° E.

The conglomerate passes into a coarse reddish sandstone which can be traced in pits and exposures northwesterly, where the same coarse red sandstone is seen to pass up into a fine grained indurated sandstone or quartzite, which in its turn passes into a fine-grained indurated argillaceous schist and chert. This indurated zone is in immediate contact with the overlying lava flow of the south trap range. The structure here is apparently that of a series of flows arising along a pipe or fissure, and shows the remains of the solidified neck with the downward bent sandstone or schist strata, together with the strong induration produced by the overflowing lava. The structure is indicated in the accompanying figure.

It may be remembered that this structure is similar to that observed by the present writer in 1879, on the Douglass Houghton and Hungarian Rivers, except that at the latter two places much decomposition has occurred, leaving it a disputed

question whether the superposition of the lava on the sandstone is due to its having flowed over it, or to a reversed fault.

In connection with the above it may be pointed out that the eastern sandstone on Traverse Island, in Keweenaw Bay, was found by the Michigan Geological Survey to dip westerly at an angle of from five to fourteen degrees, and that the present writer showed that the eastern sandstone in the vicinity of Torch Lake, generally dipped from five to twenty-three degrees northwesterly toward the copper-bearing series, and that it actually passed under the lava flows.



l, lava flows; *c*, cherty bands; *s*, *s*, indurated sandstones.

The above observations would go to show that the lava flows of the "South Trap Range," east of Lake Gogebic do not dip at a high angle, as has been generally asserted, and further that the eastern sandstone is not horizontal, as has been generally stated, but that the two dip at a low angle, generally 5° to 20°. These observations also indicate that the eastern sandstone, and the lava flows of the South Trap Range are one formation, and are as conformable as eruptions of lava can be with a contemporaneous sedimentary deposit.

The study of the South Trap Range will be continued.

Michigan Mining School, Houghton, Mich., October 1st, 1891.

ART. XLVI.—*Geological Facts noted on Grand River, Labrador;** by AUSTIN CARY.

THE map of Labrador shows on its eastern coast one deep indentation. This body of water, comprised of Hamilton inlet and Lake Melville, is 140 miles long in all, and washes at almost every point the Archæan rock of the country.

* Prof. Leslie A. Lee in planning the Bowdoin expedition to Labrador the past summer determined to send a party up the Grand River to investigate its falls and obtain such scientific information as might be possible. This paper embodies the geological facts noted by that party. Their meagerness and lack of detail must be largely attributed to the hurried nature of the trip and the serious accidents met with.

Lake Melville receives at its head three large rivers. One of these, the Grand or Hamilton river, the largest in the peninsula, prolongs for many miles the general westerly trend of the inlet. Not only this, but the valley in which it flows is a continuation of the basin of the inlet, largely similar in character, direction and width. For sixty miles the river flows on loose sedimentary material, lying again between steep rocky walls nowhere less than six or eight miles apart. The continuity of this valley, from this point to the open sea seems evident. It is a wide trough, 200 miles long, cut into the edge of the Labrador plateau and through its outlying hills.

Seldom does the river in this region touch the rocky wall, but at a point 25 miles from the mouth it has dug into the southern wall, and a remarkably round gneissic hill some 400 feet high has been formed. Here also a half mile of fall and rapid makes a drop in the river of 70 feet. At the bottom of the section of sedimentary material thus exposed, fossiliferous Champlain clays were found, the total height of the section at this point being something over 200 feet. Toward the river mouth, it gradually drops to the level of the stream, while 40 miles farther up terraced banks of sand rise to a height of 400 or 500 feet.

At a point between 60 and 70 miles from Lake Melville the sides of the rocky valley approach till they are but about a mile apart. This is well within the Labrador plateau which in this region is tolerably level, so that from the deeply sunk river bed its edges have the appearance of high, steeply sloping ridges. Parallel, and from a half mile to three miles apart, they extend for more than 200 miles, their regularity broken only by the deep-worn valleys of the largest streams, and by occasional perpendicular bluffs. Changes in direction are generally slow and easy.

Marks of former deposit and wear are everywhere. Sand terraces border the river in quiet regions, while beaches of water-worn stones mount the sides of the valley to a great height. Typical potholes were noted in one place 50 feet or more above the present river level. It is worth remark that while the general height of the plateau, as set by a former traveler* is 2000 feet; this altitude is not generally gained by a single slope. At many places when the bank rises by a steep angle or a bluff to a height of 500 or 600 feet, the remaining height is gained by a much more gradual slope.

The Grand River in this region flows through one large lake called Waminikapou. This is but a portion of the river valley 40 miles long from which the loose material has been

* Holme, Proc. Roy. Geog. Soc., April, 1888.

cleared out. From one to three miles wide, it contracts to about a quarter mile at its outlet, where the current passes out between perpendicular rocky bluffs, the talus from which serves in part to dam up the water.

Of the geological features observed on this river the great cañon at the head of our travel is judged the most remarkable. At the upper end of this structure the river, which above here has been flowing on the plateau level, makes an abrupt drop and flows off with many sharp turns, a succession of falls and rapids, between abrupt walls. These walls, without a single break, continue for 20 miles, during which they are very often absolutely perpendicular, and at few points so sloping that it is possible to reach the river's bed on foot. About 100 yards wide at the bottom, the gorge at its head is 150 feet deep, at its foot as much as 800. Grand in dimensions and unique in character as is this gorge, it has never been appreciated by the few men who have seen it. We suggest for it the name "Bowdoin Cañon."

At its mouth the cañon opens into the side of the river valley described above and at right angles to it. The difference in structure here is very marked. The broader valley extends both ways the same in direction and character; but while, as seems probable, the main drainage of the country flowed originally through this channel, it now holds but a small stream compared with the volume pouring out of the cañon.

Several interesting facts were noted at the fall which seem to determine its present position. The river above this point is flowing on a hard, moderately coarse syenite which is horizontally jointed. At the crown of the fall the jointing, as is shown by a very plain section, takes a gradual curve. This curve the water follows downward until having reached a very considerable angle, it takes a perpendicular drop. The walls of the basin into which the river falls, while inaccessible to close inspection, were intersected by what appeared to be two or three trap dikes; while just here also was a region of special jointing and seaming. Somewhat below the fall the rock was noted as having changed to a syenitic gneiss. Our party spent four days in travel on the plateau in the neighborhood of the fall and cañon. So far as observed the plateau surface is worn down to a pretty even general level with perpetual minor elevations and depressions. Almost its whole surface is covered with angular bowlders. One rounded hill, from 500 to 800 feet in height was ascended, by far the highest elevation in a radius of many miles. It was christened by the party Mount Hyde. Glacial markings and bowlders were found on its summit.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the so-called "Black Sulphur" of Magnus.*—Knapp has examined the mode of formation and the properties of the so-called "black sulphur" first described by Magnus. He finds that the best mode of preparing it is to heat suddenly a mixture of sulphur and oil; such for example as is obtained by dissolving almond oil (0·2 to 0·4 gram.) in ether, mixing the solution thoroughly with 50 grams flowers of sulphur and then evaporating the ether. If a small portion of this mixture be dropped from the point of a knife on to the bottom of a red hot platinum crucible, most of it is volatilized, but there is left a loose black residue, which after cooling is removed. By repeating the operation, the product may be increased indefinitely. Even with the greatest precautions, the yield is very small, only 0·685 gram having been obtained in this way from 100 grams of sulphur and 0·4 gram of oil, as a mean of 23 experiments. The oil treated alone in this way gave only 0·011 gram of residue. As thus obtained the "black sulphur" contains some yellow sulphur, and if the materials were not pure, also some ash. Its density varies from 2·622 to 1·843, this want of homogeneity being due to the difficulty of regulating the temperature. It is insoluble in hot and cold water, alcohol, ether, hydrochloric acid, nitric acid, aqua regia, ammonia, caustic alkalies even when concentrated, and potassium cyanide. On evaporating it with potassium hydroxide solution, it is attacked just as the hydroxide is becoming solid and dissolved to a humus-brown mass soluble in water with a deep brown color, yielding a solution in which acids give a brown precipitate. On heating the black sulphur in the air it undergoes no change other than the loss of moisture and yellow sulphur until the temperature reaches 200°–300°, when sulphurous oxide is formed. At a red heat the mass takes fire. In the absence of air, the black sulphur slowly loses weight and continues to do so for many hours even at a red heat, no vapor of sulphur or empyreumatic vapors being evolved. After the weight becomes constant, the residue burns away in the air entirely. The amount of this residue was 43·59 per cent. Its quantity did not seem to vary when the heating took place in carbon dioxide and no brown sulphur vapors appeared in the vessel, although considerable potassium sulphide was formed when the delivery tube from this vessel was conducted under potassium hydroxide solution. The sulphur in the "black sulphur" was estimated by evaporating a known portion with potassium hydroxide and potassium nitrate solutions and heating, until the residue was white. Three determinations gave 53·77, 56·76 and 57·07 per cent of sulphur, respectively. The residue left at a red heat contained 22·78 per cent of sulphur. Thus 44–46 per

cent of the sulphur is expelled at a red heat, while the residue contains 10 per cent only of sulphur mixed with 33–34 per cent of carbonaceous matter. Only 13–14 per cent of the total sulphur is dissolved by potassium dichromate and bromine. Hence the author concludes that the "black sulphur" of Magnus is not in itself a modification of sulphur, but consists of such a modification either adhering to or condensed with, a carbonization product of the oil, itself containing sulphur. The new form of sulphur does not vaporize below a temperature which is far above the boiling point of yellow sulphur. Moreover its vapor is colorless and not brown; and it evolves sulphurous oxide below a visibly red heat without combustion. Though evidently unstable in the free state, it can exist readily in contact with any surface which affords a substratum for its development. This the author finds in the blue color developed by sulphur on platinum, silver and lead sulphide, and in the blue of ultramarine.—*J. pr. Ch.*, II, xliii, 305; *J. Chem. Soc.*, lx, 877, Aug. 1891. G. F. B.

2. *On a new form of Silicon.*—Warren has described a new form of silicon crystallizing in well-defined oblique octahedrons, obtained by subjecting potassium silicofluoride to an intense heat in contact with impure aluminum. On separating the graphitoidal silicon thus produced, by the aid of acids, the new variety was obtained though only in small amount. The yield was increased by proceeding as follows: Pieces of aluminum the size of a walnut were thrown into a clay crucible containing a mixture of 4 parts of potassium silicofluoride, one part potassium carbonate and 2 parts potassium chloride, in a state of fusion. After the violent action was over, the crucible was heated to whiteness for about five minutes. On cooling a button was obtained containing 80 per cent of silicon. This was placed in a plumbago crucible with 12 parts of aluminum and 2 parts of tin and the whole was covered with a layer of sodium silicate. After heating to the highest attainable temperature for two hours, the crucible was cooled and the aluminum button was broken. It contained the new modification of silicon in large perfect crystals, having a full metallic luster and resembling the crystals of cast iron seen on breaking a pig of this metal. The silicon crystals are infusible and insoluble in all acids except hydrofluoric.—*Chem. News*, lxiii, 46; *J. Chem. Soc.*, lx, 799, July, 1891. G. F. B.

3. *On a new Alkaloid from Conium maculatum.*—The new alkaloid which was observed in *Conium maculatum* by Merck of Darmstadt, has been submitted to a careful chemical examination by Ladenburg and Adam. As received it was a white powder, easily soluble in water, alcohol, ether and benzene and forming salts with acids. The new base was purified in two ways: first by distillation and second by recrystallization from toluene. Both portions had the same melting point and both gave on analysis similar numbers: carbon 66·66 and 67·14, and hydrogen 12·33 and 12·35, the nitrogen being 9·88. This agrees

with the formula $C_5H_{11}NO$ which is that of conhydrine. Being quite similar to this base the authors call it pseudoconhydrine. It boils at 229°–231°, the distillate solidifying crystalline, and fusing at 100°–102°. It is optically active, $\alpha_D = 4{\cdot}30°$. Its constitution has not been fixed.—*Ber. Berl. Chem. Ges.*, xxiv, 1671, June, 1891. G. F. B.

4. *On Iron-tetracarbonyl and Nickel-tetracarbonyl.*—Mond and Quincke have succeeded in forming a compound of iron with carbon monoxide analogous to the compound of nickel with this gas described by them in conjunction with Langer. When very finely divided iron, obtained by reducing iron oxalate in a current of hydrogen at the lowest possible temperature, but little over 400°, and then cooled in the gas to 80° is treated with carbon monoxide, the escaping gas imparts a yellow color to the flame of a Bunsen burner into which it is passed, this result continuing even at ordinary temperature for several hours. On passing the gas through a heated glass tube at 200° to 350° a metallic mirror is formed, while at higher temperatures black flakes are produced. Upon dissolving these mirrors in acid, the solutions gave all the known reactions of iron in remarkably brilliant colors. A solution in nitric acid, precipitated by ammonia, weighed and reduced by hydrogen gave 70·48 and 69·94 per cent of iron in the oxide in two cases, the theoretical amount being 70·00. Even under the most favorable circumstances, however, the quantity of iron obtainable in this way is very small. On treating 12 grams of finely divided iron with carbon monoxide for six weeks, only about two grams of the metal volatilized. After a time the action diminished in intensity, and it was found necessary to heat the iron in a current of hydrogen at 400° for about twenty minutes every five or six hours. When 2½ liters of carbon monoxide passed per hour over the iron, the issuing gas contained not more than 0·01 gram of iron per liter; equivalent to less than 2 c.c. of $Fe(CO)_4$. Sulphuric acid absorbs the gas completely, but the solution decomposes very rapidly. Benzine and heavy mineral oils partially absorb it, producing tawny colored solutions which decompose on exposure to the air with separation of iron hydroxide. The analysis of the gas was effected by saturating a mineral oil with it by passing it through the oil for 8 to 16 hours, raising the temperature to 100° under a pressure of 500 mm. of mercury to free it from air and dissolved CO, and then to 180°, at which temperature the iron compound was decomposed, the carbon monoxide being evolved and the iron separating in the metallic form. The ratio of the CO to the Fe was found to be in five experiments 4·144, 4·030, 4·150, 4·264, and 5·042; thus rendering it probable that the substance is iron-tetracarbonyl, corresponding to the nickel compound. The authors suggest that this iron compound may play a part in the process of cementation.—*J. Chem. Soc.*, lix, 604, Aug., 1891; *Ber. Berl. Chem. Ges.*, xxiv, 2248, July, 1891. G. F. B.

BERTHELOT also has observed the formation of this iron-carbonyl compound. If finely divided iron, obtained by reducing the precipitated oxide at the lowest possible temperature or by igniting the oxalate in hydrogen, be treated at 45° with carbon monoxide, the escaping gas contains iron and burns with a brighter, sometimes whiter, flame than the monoxide itself. This flame produces spots on a porcelain surface held in it, these spots consisting of iron and its oxide. On passing the gas through a heated tube a metallic ring is deposited consisting of iron containing carbon. With concentrated hydrochloric acid, the gas gives ferrous chloride. On standing over water containing air, iron oxide is deposited. The quantity of the iron compound is very small. Berthelot has also examined nickel-tetracarbonyl and finds that it is permanent and without marked dissociation-pressure at ordinary temperatures. When preserved under water it is not decomposed if air be absent. When heated suddenly to above 60° it explodes, producing carbon and carbon dioxide besides nickel and the monoxide; according to the equation $C_4O_4Ni = (CO_2)_2 + C_2 + Ni$. It is not soluble in water, dilute acids or alkalies or acid cuprous chloride; though hydrocarbons, especially oil of turpentine dissolve it. Mixed with air or oxygen it detonates on ignition and sometimes spontaneously as when the dry gas mixed with oxygen is agitated over mercury. In presence of water, a greenish-white gelatinous precipitate is formed which contains nickel, oxygen, water and combined carbon, and which deposits carbon on heating. In the liquid state, nickel-tetracarbonyl shows similar reactions. Concentrated sulphuric acid explodes it, while its vapor when mixed with nitrogen is gradually converted by this acid into four times it volume of carbon monoxide, the nickel going into solution. Ammonia does not act at once on the pure gas, while if oxygen be present white fumes appear immediately. Hydrogen sulphide gives a black sulphide, hydrogen phosphide a black mirror-like deposit. Nitrogen dioxide when mixed with the liquid or its vapor, produces a blue cloud which gradually sinks to the bottom of the vessel; the resulting gaseous mixture containing nitrogen dioxide, carbon monoxide and a new nickel compound. The author calls attention to the analogy between carbon monoxide and the radicals contained in the so-called metallo-organic compounds.—*C. R.*, cxii, 1343; *Ber. Berl. Chem. Ges.*, xxiv, Ref. 593, July, 1891.

G. F. B.

5. *On a sensitive Reaction for Tartaric acid.*—MOHLER has observed that when crystals of tartaric acid are thrown on sulphuric acid of 66° B., containing one per cent of resorcinal, and the whole is heated gradually, a fine red-violet coloration is produced when the temperature approaches 125°; complete carbonization taking place at 190°. Water destroys the color. The coloring matter could not be isolated since it was not soluble in ether, amyl alcohol, acetone, chloroform, or benzine. Using other phenols, similar colors are produced; phloroglucinol giving a red

and pyrogallol a fine violet color. Since these reactions are not given by succinic, malic, citric or benzoic acids, tartaric acid may readily be detected when mixed with any of these acids. To detect 0·01 milligram, the author evaporates the solution to be tested to dryness, one c.c. of the resorcinal solution is added, and the whole is gradually heated to about 125°. At first reddish streaks appear and then the sulphuric acid becomes colored throughout. If organic substances which char with sulphuric acid are present, the tartaric acid is removed by precipitation as lead tartrate and then tested, nitrates and nitrites should not be present.—*Bull. Soc. Chem.*, III, iv, 728; *J. Chem. Soc.*, lx, 867, July, 1891.

G. F. B.

6. *Photography of the Spectrum in natural color.*—H. W. Vogel gives a historical account of the photography of color and an explanation of the failures to accomplish it. It appears that Zenker, in 1868, indicated the method of depositing layers of silver of suitable thickness to produce by interference of light colored photographs, a method which Lippman has lately developed. Lord Rayleigh's (1886) explanation of the colors in photographs produced by adjusting the layers of silver to wave lengths in order to produce colors by interference is a repetition of the explanation of Zenker. In the earlier processes Ag_2Cl was used in the sensitive film and the fixing of the image produced in this film, by hyposulphite of soda, destroyed by separation of fine silver particles the regular layers which were necessary to produce interference colors. Lippman uses pure bromide of silver which, under the operation of fixing, leaves the film in homogeneous, regular layers suitable for producing interference colors.—*Verhandl. d. Physik. Ges. Berlin*, 10, p. 33, 1891; *Photogr. Mittheil.*, 28, p. 7.

J. T.

7. *Discharge of Electricity through exhausted Tubes without Electrodes.*—J. J. Thomson points out that the oscillations of the discharge from a Leyden jar produce during the short time of their duration enormous currents in the wire connecting the coatings of the jar, and therefore produce by induction very great electromotive force in the neighborhood of the wire. He therefore investigates the discharge by induction in rarefied vessels by wrapping these vessels with the wire connecting the coatings of a Leyden jar; thus producing luminous discharges in these vessels without the direct passage of electricity from metallic terminals in the gas. Professor Thomson points out that the phenomena bear upon his theory of tubes of electrostatic induction. He regards the distinction between electrostatic and electromagnetic electromotive forces as one introduced for convenience of analysis rather than as having any physical reality. "The only difference which could be made, from a physical point of view, would be to define those effects as electrostatic which are due to tubes of electrostatic induction having free ends, and to confine the term electromagnetic to the effects produced by closed endless tubes. It is only when the electromotive forces are produced ex-

clusively by the motion of the magnets that all the tubes are closed : whenever batteries or condensers are used, open tubes are present in the field." The bearing of Professor Thomson's experiments on the aurora is extremely interesting. The most remarkable appearance was presented when the discharge passed through oxygen. In this gas the bright discharge is succeeded by a phosphorescent glow which lasts for a considerable time, sometimes for more than a minute. The spectrum of the afterglow is a continuous one, without bright lines. The only gas besides oxygen which shows the afterglow is air. The spectrum of the air glow showed bright lines. Professor Thomson is continuing his investigation.—*Phil. Mag.*, Oct., 1891, pp. 323–336. J. T.

8. *Ratio of Electromagnetic to Electrostatic units.*—J. J. Thomson and G. T. C. Searle have undertaken a redetermination of the value of this ratio. A complete account of their experiments can be found in *Phil. Trans.*, Lond., 181 A., pp. 583–621, 1890. The value obtained is $v = 2{\cdot}9955 \cdot 10^{10}$ cm. sec.$^{-1}$.

J. T.

9. *Expansion of Water.*—A useful table of the expansion of water from temperatures 0° to 31° is given by W. Marek.—*Ann. der Physik und Chemie*, No. 9, 1891, p. 171. J. T.

10. *Experiments in Aerodynamics*, by S. P. Langley. 115 pp. 4to, with 10 plates. Washington, 1891 (Smithsonian Contributions to Knowledge, 801).—When the investigation of a subject like that of "flying machines"—at once so stimulating to the popular imagination and yet almost an *ignis fatuus* in the view of sober minds—is made the subject of careful scientific experiment in skillful hands the results are sure to be of unusual interest and value. This is eminently true of Prof. Langley's investigations in aerodynamics which briefly demonstrate experimentally that mechanical flight under proper direction is practicable and further that the support of heavy bodies in the air, combined with very great speeds is not only possible but within the reach of mechanical means now available.

The experiments detailed in this memoir were carried on at Allegheny Observatory between 1887 and 1891. They describe in the first place the "suspended plane"—a thin brass plane a foot square weighing two pounds hung vertically by a spring from a surrounding frame and capable of receiving rapid lateral motion. Briefly expressed the important result of the experiments is to prove that the downward pressure diminishes as the velocity increases, the spring contracting as the plane is carried forward. A second instrument served to show graphically the direction of the total resultant pressure on a square inclined plane and to roughly measure its amount—this is called the "resultant pressure recorder." Still another instrument, the "plane-dropper," was used to demonstrate that a horizontal plane in lateral motion requires an increased time for its descent, and also to measure the time of fall for different planes and other related points, thus giving the soaring speeds of wind-planes

set at varying angles and making it possible to compute the work expended in their uniform horizontal flight. Thus it is proved that less work is required in the aerial motion of heavy inclined planes at higher speeds than at lower ones. In the quantitative experiments connected with this part of the subject, a "component pressure recorder" was used together with a "dynamometer-chronograph" to record the speed, the resistance to forward motion at the instant of soaring and other attendant phenomena.

Reference must be made to the memoir itself for the details of the methods and results of the experiments with the instruments, alluded to. It is interesting, however, to note the conclusion reached, that, "so far as the mere power to sustain heavy bodies in the air by mechanical flight goes, such *mechanical flight is possible with engines we now possess*, since effective steam engines have lately been built weighing less than 10 pounds to an horse-power, and the experiments show that if we multiply the small planes which have been actually used, or assume a larger plane to have approximately the properties of similar small ones, one horse power rightly applied can sustain over 200 pounds in the air at a horizontal velocity of over 20 meters per second (about 45 miles per hour) and still more at still higher velocities." The author adds further that the experiments "afford assurance that we can transport (with fuel for a considerable journey and at speeds high enough to make us independent of ordinary winds) weights many times greater than that of a man." He goes on to say (we quote the author's words) that he has "not asserted without qualification that mechanical flight is practicably possible since this involves questions as to the method of constructing the mechanism, of securing its safe ascent and descent and also of securing the indispensable condition for the economic use of the power I have shown to be at our disposal, the condition, I mean, of our ability to guide it the desired horizonal direction during transport—questions which in my opinion are only to be answered by experiment and which belong to the inchoate art or science of *aerodromics* on which I do not enter. I wish, however, to put on record my belief that the time has come for these questions to engage the serious attention not only of engineers but of all interested in the possibly near practical solution of the problem, one of the most important in its consequences of any which has ever presented itself in mechanics; for this solution it is here shown cannot longer be considered beyond our capacity to reach."

11. *The Chemical Analysis of Iron.*—A complete account of all the best known methods for the analysis of iron, steel, pig-iron, iron-ore, limestone, slag, clay, sand, coal, coke and furnace and producer gases by ANDREW ALEXANDER BLAIR. Second edition. 314 pp. Philadelphia, 1891 (J. B. Lippincott Company).—The first edition of this valuable and attractive work was noticed in volume xxxvi (p. 387) of this Journal. In the

present edition some new analytical methods have been added, the table of atomic weights has been revised and the errors noted during its use for the past three years have been corrected.

12. *Die Fortentwickelung der elektrischen Eisenbahn-Einrichtungen*, von L. KOHLFÜRST. Vienna, 189 (A. Hartleben's Verlag).—This volume is published in the same form as those of the "Elektro-technische Bibliothek" repeatedly noticed in this Journal. It is devoted to the various applications of electricity to railroad traffic, in the telegraph, telephone, signals, etc., and gives much information on these practical subjects compressed into a small space.

II. GEOLOGY AND MINERALOGY.

1. *Report of Exploration of the Glacial Lake Agassiz in Manitoba;* by WARREN UPHAM. 156 pages 8vo, with two maps and a plate of sections; forming Part E, Annual report of the Geological and Natural History Survey of Canada, vol. iv, for 1888–89.—The departure of the ice-sheet of the Glacial period is shown to have been attended with the formation of a vast lake in the basin of the Red River of the North and of Lake Winnipeg, held by the retreating ice-barrier. It exceeded in extent the combined areas of the great lakes tributary to the St. Lawrence, and had a maximum depth of about 600 feet. Seventeen shore-lines, marked by beach-ridges of gravel and sand, are found at successive levels upon the northern part of this lacustrine area which are referable to stages of the glacial lake while it outflowed southward by way of Lakes Traverse and Big Stone and the Minnesota River. At lower levels, eleven later shore-lines belong to stages of outflow northward, previous to the recession of the ice from the region crossed by the Nelson River, whereby Lake Agassiz was reduced to Lake Winnipeg. The earliest and highest beaches have a gradual ascent of about one foot to the mile northward along an explored extent of 400 miles from south to north; but in the lower beaches there is a gradual decrease of this ascent, and the latest and lowest beaches are very nearly level. It is thus known that the area of Lake Agassiz was undergoing a differential northward uplift during the time of the ice-departure, and that the uplift was nearly completed within that time. On the adjoining country of Minnesota and North Dakota eleven distinct terminal and recessional moraines indicate the maximum extension of this ice-sheet and stages of halt or re-advance interrupting its general retreat; and five of these moraines, namely, the Dovre, Fergus Falls, Leaf Hills, Itasca, and Mesabi moraines, were accumulated after Lake Agassiz began to exist in the Red River Valley.

An appendix of this report gives a tabulation of glacial striæ on the region of Lake Agassiz and the country northward to Hudson Bay and the Mackenzie; and another appendix notes altitudes determined by the Canadian Pacific railway surveys in Manitoba and westward to the Pacific.

2. *Geological Survey of Texas, 2nd Annual Report*, 1890. E. T. DUMBLE, State Geologist. 756 pp. 8vo, with maps, plates and sections. Austin, Texas, 1891.—The introductory chapter of this second Annual Report by Mr. Dumble reviews the work of the year, and the subjects of metallic and other mineral and economical resources of the State. It is followed by an account of the geology and resources of the iron ore district of East Texas, by E. T. Dumble, Wm. Kenedy, J. H. Herndon and J. B. Walker; on the geology of northwestern Texas, by W. F. Cummins; on the geology and resources of the central mineral region of Texas, by T. B. Comstock; and on the geology and mineral resources of Trans-Pecos, Texas, by W. H. von Steeruwitz, with a report on the Cretaceous rocks of the region by J. A. Taff.

Mr. Cummins, in his account of the Permian—the lower division of the Red Beds,—makes them in places 5000 feet thick, and every where conformable with the Carboniferous. He divides the formation into the Wichita or Lower, consisting of sandstones; the Clear Fork beds, limestones, shales and sandstones, and some gypsum; and the Double Mountain beds, including limestones, shales and thick beds of gypsum. The overlying Triassic commences with sandstones and conglomerates, which resemble and are supposed to be the equivalent of the Shinarump conglomerate of Powell—made the beginning of the Trias by Mr. C. D. Walcott. The Permian series is not separable from the Triassic by any marked unconformability, yet it is evident, Mr. Cummins remarks, that there was not continuous sedimentation between the two.

3. *Preliminary Notice of a New Yttrium-Silicate;* by W. E. HIDDEN. (Communicated).—Associated with the huge crystals of gadolinite, with yttrialite and the other yttrium minerals, found in Llano County, Texas, two years ago, I have discovered a few masses of a new species that is exceedingly rich in the yttrium earths. A preliminary examination has shown its density to be 4·515. Its color is pale drab-green when pure. In thin splinters it is perfectly transparent. Its alteration products are of a waxy brick-red color and quite easily distinguished from those of gadolinite and allanite. It is easily soluble in acids, leaving gelatinous silica. The following are the results of an unfinished analysis by the writer:

SiO_2	25·98	
Y_2O_3 etc.	61·91	atomic weight = 118.
FeO	4·69	
UO_2	0·40	
CaO	0·19	
Ign. loss	2·01	

No thoria is present and but very little of the cerium earths. The oxygen ratio of the bases found to the silica is 83·47 : 86·60, or pointing to 1 : 1 if the analysis had been completed. Its for-

mula would then be 3 SiO_2, $2R_2O_3$ or of a mineral quite distinct from the gadolinite and yttrialite with which it is found associated. For this silicate so remarkably rich in yttria, I propose the name of ROWLANDITE, after Professor Henry A. Rowland, whose spectrographic work on the so-called "rare-earths" is so novel and important. As opportunity offers a more extended description will be given of this very interesting new species.

4. *Anatase from the Arvon Slate Quarries, Buckingham Co., Va.;* by GEORGE H. WILLIAMS (communicated).—The rarity of American localities for anatase is a sufficient warrant for recording a recent discovery of this mineral in its original position, made by the writer during June last. In the course of a trip through central Virginia occasion was taken to visit the State quarries five miles south of Bremo Bluffs on the James River railroad in Buckingham County. The largest of these quarries, belonging to the Williams Brothers, is situated at the terminus of the short branch railroad, Arvon station. This contains the best quality of slate, but it is proportionately devoid of anything of mineralogical interest. About a mile west of this place, however, where the slate of this district was first opened in what is now known as the Robert's quarry, the cleavage is less perfect and regular, while cross joints are of frequent occurrence. These irregularities, which detract so seriously from the economic value of the slate, make this quarry more interesting than the other to the geologist and mineralogist. Here beautifully crinkled varieties of slate occur, and one regularly mottled sort is quite abundant, which in the field was surmised to contain ottrelite, but was found on more careful examination to owe its knots ("knoten") to small rhombohedrons of some carbonate which is but feebly transparent on account of the great number of inclusions, probably of carbonaceous matter, which it contains. Huge blocks of this imperfect or "bastard slate" have been thrown aside as worthless, and it was on the end of one of these, cut off very evenly at right angles to the cleavage by a cross joint, that the anatase crystals were found.

The surface presented by this joint plane was of large size and was completely covered with small quartz crystals, among which were scattered minute individuals of pyrite and the anatase. The latter was fairly abundant and closely resembles the black, metallic, steep pyramidal variety, so well known from the Tavetsch valley in Switzerland. Hardly any crystals were noticed over a millimeter in length, while most were less than this. No forms except the unit pyramid, 1 (111), and the base, 0 (001), were observed. The pyramidal faces are horizontally striated and often built up into little flights of steps by an oscillatory combination, as is so frequently the case with the Swiss crystals. The faces have a high metallic luster but are broken by growth, irregularities, and vicinal planes, which makes the reflected images multiple and the measurements unsatisfactory. The best crystal gave :

(111) : (1$\bar{1}$1)	98° 7′	97° 51′ (calc. v. Kok.)
(111) : (001)	111° 36′	111° 42′
(111) : (11$\bar{1}$)	136° 20′	136° 36′

The smaller crystals when placed under the microscope are found to be translucent with a rather pale yellow color, metallic lustre, and high refractive index. These show parallel extinction and a uniaxial figure.

I am indebted to my friend, Prof. W. G. Brown of Washington and Lee University, for chemically examining one of the crystals, which he found to be composed largely of titanic oxide.

Baltimore, Aug., 1891.

5. *Ilvaite;* by G. Ch. Hoffmann (communicated).—Several specimens of what proved to be the rare mineral, ilvaite, were received for identification from a gentleman who described it as occurring in large irregular masses in a vein about twenty feet wide, near the head of Barclay Sound, Vancouver Island, British Columbia. Portions of the material were fairly free from foreign admixture containing only small quantities of a white translucent, cleavable calcite, this, however, was in some fragments supplemented by inclusions of altered tremolite, and in others by a brownish-yellow andradite. It had a more or less closely compacted crystalline structure. The lateral faces of crystals were not infrequently striated longitudinally, and sometimes exhibited a slight iridescent tarnish. Color, iron-black; streak, greenish-black; luster, sub-metallic, brittle; fracture, uneven. Before the blow-pipe fuses quietly at about 2·5 to a black magnetic globule. Hardness, 5·5; specific gravity, 3·85. Readily decomposed by hydrochloric acid, forming a yellow jelly.

An analysis conducted upon very carefully selected and prepared material, dried at 100° C., afforded the following results:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	H_2O
29·81	0·16	18·89	32·50	2·22	13·82	0·30	1·62 = 99·32

6. *Synthese du Rubis*, par E. Fremy. 30 pp. 4to, with 28 colored plates. Paris, 1891, (Vve. Ch. Dunod.)—The synthetic formation of minerals in general is a subject of great interest and one in which French chemists have made remarkable progress of late years. The results reached by one of the laborers in this field, M. Fremy, in the artificial production of rubies are given in this beautiful volume. In the most successful method, the rubies were obtained in an earthen crucible by the reaction at a very high temperature of a mixture of alumina (with more or less potash) upon barium fluoride, with bichromate of potash as coloring matter. They are well crystallized, clear, of brilliant color and sometimes weigh one-third of a carat. The author claims for them usefulness both in jewelry and in watchmaking. A series of fine colored plates show sections of the crucibles with the rubies scattered through the gangue, also clear isolated rhombohedral crystals (magnified), and further, the rubies cut and mounted for ornament in various forms.

7. *Brief notices of some recently described minerals.*—BRANDTITE. A hydrous arsenate of manganese and calcium, formula $Ca_2MnAs_2O_8+2H_2O$, found at the Harstig mine, near Pajsberg, Sweden. It is analogous to roselite and fairfieldite in composition and closely similar to the former species in its triclinic crystals. The color is white with vitreous luster, hardness =5–5·5; sp. gravity =3·671. An analysis gave:

As_2O_5	P_2O_5	MnO	CaO	PbO	FeO	MgO	Cl	H_2O	insol.	
50·48	0·05	14·03	25·07	0·96	0·05	0·90	0·04	8·09	0·04	= 99·71

Named by Nordenskiöld and later described by Lindström.—*G. För. Förh.*, xiii, 123, 1891.

GANOPHYLLITE.—A hydrous silicate of alumina and manganese from the Harstig mine, Sweden. It occurs in monoclinic crystals with perfect basal cleavage. The color is brown; hardness =4–4·5; sp. grav. =2·84. An analysis gave:

SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	PbO?	K_2O	Na_2O	H_2O	
39·67	7·95	0·90	35·15	1·11	0·20	0·20	2·70	2·18	9·79	= 99·85

The formula calculated is $7MnO . Al_2O_3 . 8SiO_2 . 6H_2O$; the author, A. Hamberg, proposes to include it among the zeolites.—*G. För. Förh.*, xii, 586, 1890.

PYROPHANITE.—A manganese titanate, $MnTiO_3$, like the preceding species from the Harstig mine. It occurs in rhombohedral crystals isomorphous with hematite and ilmenite and is probably tetartohedral like the latter species. The color is deep blood-red; hardness =5; sp. grav. =4·537. An analysis gave:

TiO_2	MnO	Fe_2O_3	Sb_2O_3	SiO_2	
50·49	46·92	1·16	0·48	1·58	= 100·63

Also described by Hamberg, *ibid.*

OFFRÉTITE.—A new zeolite near phillipsite in composition, from Mt. Simionse, Montbrison, France. It occurs in white hexagonal crystals with sp. grav. =2·13. An analysis gave:

SiO_2	Al_2O_3	CaO	K_2O	H_2O	
52·47	19·06	2·43	7·72	18·90	= 100·58

Described by F. Gonnard, *C. R.*, cxi, 1002, 1890.

KALLILITE.—A nickel ore from the Friedrich mine near Schönstein a. d. Sieg. It occurs in massive form with a light bluish gray color. Analysis gave:

S	Sb	As	Bi	Ni	Fe	Co	
14·39	44·94	2·02	11·76	26·94	0·27	0·89	= 101·21

This corresponds essentially to NiSbS. Described by Laspeyres, *Zs. Kryst*, xix, 12, 1891.

SYCHNODYMITE.—A cobalt ore also described by Laspeyres (l. c., p. 17) from the Kohlenbach mine at Eiserfeld near Siegen. It occurs in isometric crystals of a dark steel-gray color. Analysis gave:

S	Cu	Co	Ni	Fe	
40·33	17·23	35·64	5·74	0·82	= 99·76

This corresponds to $(Co, Cu, Ni)_4S_5$, like polydymite.

UMANGITE.—A selenide of copper occurring with eucairite in the Sierra de Umango, Argentine Republic. It occurs in fine granular massive forms, with metallic luster, dark cherry-red color; hardness =3; sp. grav. =5·620. Analysis gave:

Se	Cu	Ag	Fe
36·18	44·27	0·45	0·16

The calculated analysis is Cu_3Se_2. Described by F. Klockmann, *Zs. Kryst.*, xix, 269, 1891.

ANTLERITE.—A basic sulphate of copper of a light green color, occurring in massive form at the Antler mine, Yucca Station, Mohave Co., Arizona. After deducting 6 to 8 p. c. gangue, the mean of two analyses gave :

	SO_3	CuO	ZnO	CaO	H_2O
Sp. grav. = 3·93	20·98	67·91	0·16	0·05	10·94 = 100·04

The formula suggested is $3CuSO_4 . 7Cu(OH)_2$. Described by W. F. Hillebrand, *Bull. 55, U. S. G. Surv.*, p. 54, 1889.

PLUMBOFERRITE.—A mineral from the Jakobsberg mine, Nordmark, Sweden, occurring in black cleavable masses. Analysis gave :

Fe_2O_3	PbO	FeO	MnO	MgO	CaO
60·38	23·12	10·68	2·20	1·95	1·67 = 100

Described by Igelström in 1881, and again in 1891, *Zs. Kryst.*, xix, 167.

8. *Catalogue of Minerals and Synonyms*, by T. EGLESTON, 378 pp. 8vo. New York, 1891 (John Wiley & Sons).—The mineral collector, perplexed by the confusing multiplicity of mineral names, will find much assistance from the present volume. It gives a very full alphabetical list of mineral synonyms with references to the names of the recognized species, under which they are arranged chronologically with the author's name. This work is expanded from a similar earlier list, which appeared as Bulletin 33, of the U. S. National Museum (noticed in this Journal, xxxviii, 494, 1889).

III. BOTANY.

1. *Some Museums and Botanical Gardens in the Equatorial Belt and the South Seas.*—(Fourth paper). The Queensland Museum, at Brisbane, under the charge of Mr. de Vis, is rich in specimens illustrating the Natural History and Ethnology of the Colony. It is well arranged, although much crowded, and is thoroughly appreciated by the community. Here, as elsewhere in the Colonies, much attention is paid to the collection and conservation of objects which are of special significance in the locality : hence many of the collections are treasure-houses of incalculable value to the colonial and to the general student. Even the smaller collections of minerals and of aboriginal curiosities are well managed, so that the amount of material at the command of a student in any of the departments of Natural History, Geology, Ethnology, and Anthropology, is large and readily available. To this is to be added the statement, that the Curators of the collections, although sedulously guarding the unique specimens, afford every facility for their comparison and examination.

The voyage from Brisbane northward to Java is intensely interesting. In the first place, the steamers stop at various points

along the coast of Queensland, giving opportunity for a hasty glance at the natural features, while in the second place, the waters through which one sails, are protected by the long barrier reef. These coral reefs extend from 24° 30′ south latitude as far as Torres Straits at the North, in latitude 10°. The distance between the irregular reef and the shore varies greatly, being in some places about one hundred miles, in others less than ten miles. For a good part of the voyage near the upper extremity of the great York peninsula, the shore is plainly in sight, while on the other side of the ship one can see the low-lying islands of the Barrier Reef. The whole distance from Brisbane to Thursday Island, 1430 miles, is under the direction of coast pilots.

The voyage at this part is almost like a sail along the banks of a wide river. The shore is frequently fringed by mangroves, while on the higher land the tropical trees are thickly crowded. For considerable distances, the steamer keeps so close to the shore, that one can discern the habit of the larger trees. At certain straits one can see distinctly even the hills of the white ants, and the forms of the lower shrubs.

It is impossible to forget, as one sails along this coast, how closely every part is connected with the discoveries of Capt. James Cook. The names of some of the headlands and bays bear witness to the arduous efforts of this intrepid navigator, and serve as the lasting memorials of the perils and adventures of Cook's "first voyage." Among these names are: Weary Bay, Cape Flattery, Cape Tribulation, Repulse Island, and so on; together with many which simply note the dates on which the places were touched during the voyage, such as Whitsunday Passage, Pentecost Island, Wednesday Island, Thursday Island. The place last named has the safest harbor in the region. It is at this point that the coast pilot relinquishes his charge to the captain.

At Thursday Island, our ship was placed in quarantine, owing to a case of supposed scarlatina. This disease had been epidemic at our port of departure, Brisbane, and a single slight case on board appeared to justify the health officer of the port in preventing any of the passengers from landing. Therefore we remained nearly a day in sight of an interesting shore, with no opportunity to visit it or receive collections from it.

The passage through Torres Straits is considered one of the most dangerous bits of navigation in the world, owing to the presence of numerous small islands and hidden reefs, with currents which are as yet not fully understood. It was at this place that the "Quetta" sank just one year before we passed the spot; her commander was in charge of our own steamer and gave us harrowing details of that disaster.

At Torres Straits we were only a few miles from the southern part of New Guinea, but we passed it at night and did not catch a sight of land. The first land sighted, but still at a considerable distance, was Timor Laut, after we had traversed the Arafura

Sea. Many of the larger islands in the lower part of the Banda and Flores seas are seen plainly, the steamer often going near enough to enable passengers to make out points of interest on land. Every facility was afforded me for securing photographs of this region. Some of the views are fairly satisfactory. Sumbawa, Lombok, Bali and Madura, are among the vivid recollections of this portion of the voyage. The volcanic character of the commanding mountains which, with their outlying flanks, make up the islands, is impressed upon every feature of the scenery. The same is true of the long island of Java which we skirted on its northern side.

At Tanjong Priok, Java, the harbor of Batavia, we were everywhere surrounded by tropical vegetation. All the land there lies very low, and has a bad reputation on account of the fevers prevalent at the coaling station. Passengers make their way, past very considerate custom-house officials, to the train in waiting, and thence over a level plain, to Batavia, a few miles away. The city of Batavia is full of interest to a naturalist, but the attractions at points farther up the railroad leave but scant time for the city.

My objective point was, of course, Buitenzorg, the locality of the famous garden. For a good many years, accounts by friends in Holland had led me to form high expectations with regard to this Javan garden. I may say that in no respect were these expectations unrealized. It is impossible, as I have said in a former paper, to compare the garden at Péradeniya, in Ceylon, with this in Buitenzorg, although they belong to the same class. No intelligent visitor can fail to be gratified by these glimpses of well-arranged tropical vegetation: if the traveler can take into his tour both of the gardens, by all means let him do so; but let him not fail to go out of his way to see at least one of them.

Etymologically, Buitenzorg is almost the exact equivalent of *Sans Souci;* besides, each has its palace. Hence, as might be inferred, Buitenzorg possesses a strong park-like character at that portion which is near the government grounds. Aside from this, the arrangement is that of a botanic garden proper, and everything is made tributary to it.

The large specimens of trees have proved in some cases embarrassing to the director in his endeavors to rearrange the plants, but he has wisely left the most important of these in their old places, seeing to it, however, that they are so conspicuously labelled that no confusion is likely to result.

At the time of my visit, a display of tropical fruits had been arranged in one of the large plant houses for the inspection of the Crown Prince of Russia, and I had the pleasure of examining carefully what was considered one of the largest collections ever brought together. Nothing could give a better idea of the immense resources of the garden.

Dr. M. Treub, the Director of the Garden, has carried out well-matured plans for the establishment of a station for phyto-

logic study, and the government has given him adequate support. In his admirable laboratories, students can find every appliance for their investigations. The *Annals of the Botanic Garden at Buitenzorg* show how well these advantages have already been improved. Dr. Treub authorizes me to state to American students of Botany, that he would be happy to communicate with any who are prepared to undertake special investigations. Arrangements are now in progress at Cambridge, by which it may be possible for one American student of Botany to be supported in Buitenzorg, for a term of one year: it is among the possibilities that a fund may be obtained by which such an subvention may be made permanent, and that American botanists may have this privilege of examining tropical plants under the most favorable conditions. It is not amiss to say in connection with this subject that the climate of Buitenzorg is healthy and agreeable, and also that the surroundings are exceedingly interesting in numerous ways.

On a contiguous mountain, the garden supports an annex. Here are cultivated the plants which are impatient of the temperature of Buitenzorg. Experiments in acclimatization can be carried on in both places. Not very far away from the the main garden, are the economic grounds, and in these are the laboratories recently established to supplement those at the main garden. The products of useful plants can here be examined chemically and physically, by the side of the plants which produce them. The suites of varieties under cultivation are very large, and constantly receive additions from other tropical regions.

It is needless to say that the region lying to the east of Buitenzorg, the hill country, with its ruined temples and with its active volcanoes, ranks among the most interesting places in the world, whether regarded from an ethnological or a geological point of view.

The voyage from Batavia to Singapore, 380 miles, takes one past the island of Banca and close by Sumatra, but the vegetation cannot be made out clearly except at one or two points.

The garden at Singapore, under the direction of Mr. Ridley, is very attractive. The plants are in good condition and everything is kept up to a high standard of efficiency. Here also there is an experimental garden filled with useful plants in great variety. Mr. Ridley has wisely left one part of his garden in its wild state. In this bit of untouched jungle, uninvaded by even a single foreign plant, except at the border, one can see many of the tropical plants in the thickest of their unrelenting struggle for existence. With creepers swaying from the lofty tropical trees, intertwined in confused tangles; with pitcher-plants at one's side and under foot; with the chatter of monkeys overhead, and the cries of the startled birds all around, one can appreciate the endless variety of organisms in favored regions in the tropics. The Malaccan garden which lies a short distance to the north of Singapore I did not have time to visit.

The last of the tropical gardens seen by me on the present journey was in French China, at the city of Saigon. Everything

here was frightfully dry after a comparatively rainless season, but strenuous efforts were being made to renovate the grounds before the arrival of the Russian Crown Prince. The grounds appeared to have been given up almost as much to an attempt to make a Zoological Garden as a Botanical one, but many of the animals had been temporarily carried to another place, and the display was very meagre. The plants were mostly young and although very interesting, possessed no features worthy of special remark. The supply of water for the garden at Saigon did not seem copious or good. Under such circumstances, it must be a discouraging task to organize a botanic garden. At the time of my visit, the directorship was vacant, and the grounds were in charge of a foreman. The gardens are here, as in other tropical ports, one of the principal attractions for the steamship passengers and for the townspeople. This fact leads the directors to make the grounds as attractive as possible from a scenic point of view, without injuring them for the purposes for which they are primarily designed.

Hong Kong has a very charming park which may also rank as a Botanic Garden. It is beautifully laid out on a very irregular hill or series of slopes. Many of the specimen trees are in excellent condition, and all of them are effectively grouped.

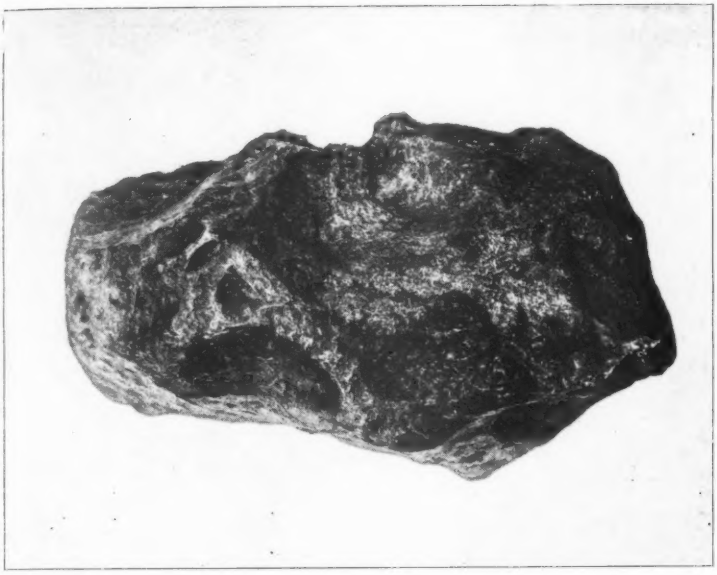
The small parks at Shanghai cannot in their present condition be regarded as gardens. The climate favors the growth of warm temperate plants, and these, as cultivated in the private gardens of the China coast, are said to be among the most interesting examples of Chinese horticultural work accessible to visitors. Time did not permit me to examine any of them. G. L. G.

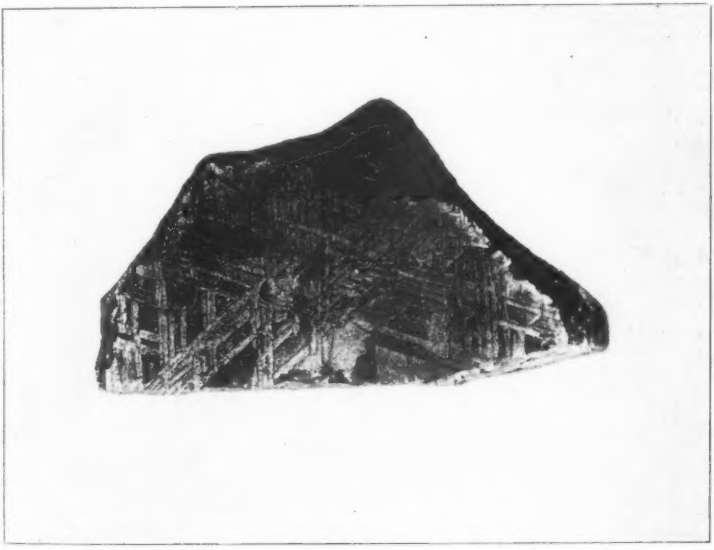
IV. Miscellaneous Scientific Intelligence.

1. *Leidy Memorial Museum.*—As a memorial to the late Dr. Joseph Leidy it is proposed to raise a fund to establish and endow the Leidy Memorial Museum as an independent part of the great museum now forming at the University of Pennsylvania. The amount desired for this purpose is $50,000. The interest derived from this fund will be devoted exclusively to Dr. Leidy's family during the lifetime of his widow. Subscriptions may be made payable at once or in instalments extending over two or three years as may be approved by the donors. Contributions of all sizes will be received gladly; it is designed to make this a general tribute. Checks should be drawn to the order of Robert R. Corson, Treasurer, 37 Forrest Building, Philadelphia, Pa.

2. *Bibliotheca Zoologica*, II, Dr. O. Taschenberg. Neunte Lieferung, sig. 321–360, pp. 2611–2928. Leipzig, 1891 (Wm. Engelmann).—The ninth part of this great work has recently appeared, containing the closing part of the bibliography on Insects, also on Molluscoidea, from Bryozoans to Gasteropods.

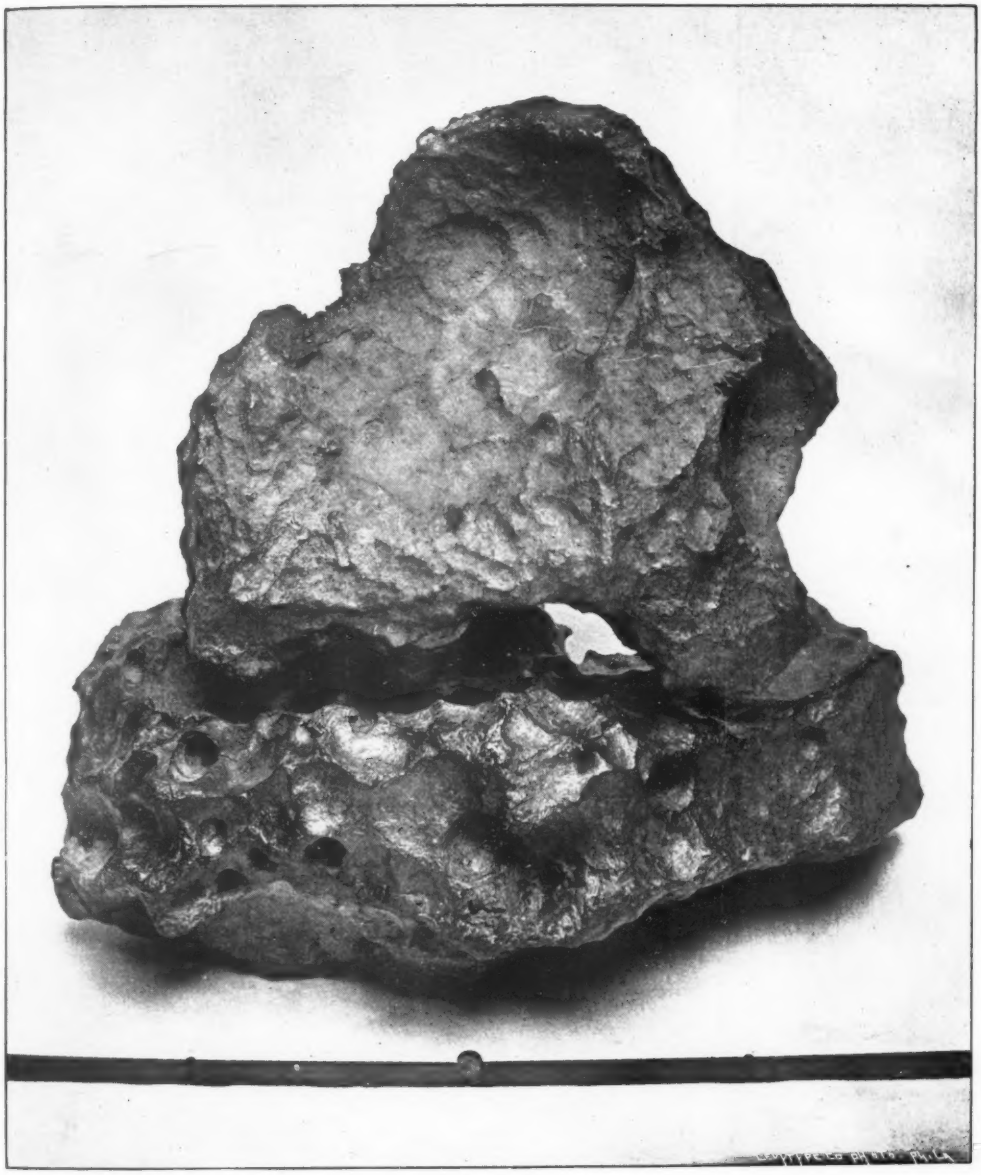
3. *Catalogue of Minerals.*—Messrs. George L. English & Co. have issued a supplement of 20 pages to their Catalogue of Minerals. It gives a list of new species, with republished notes on various old species, especially of American source.





TONGANOXIE METEORITE.

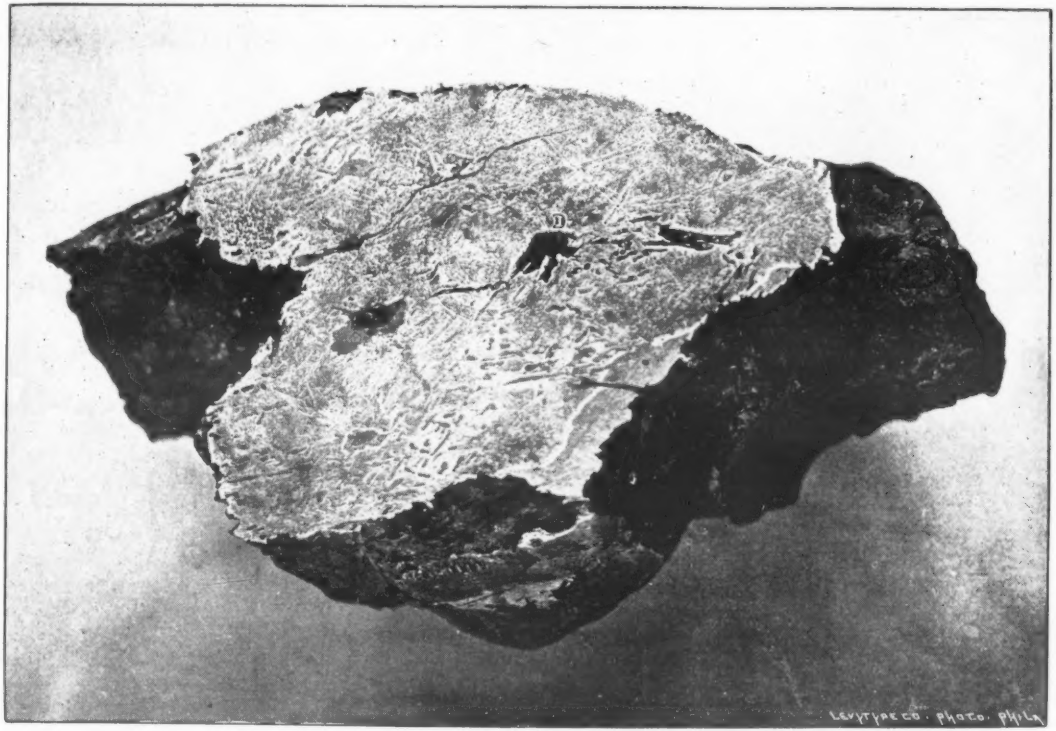
FIG. I.—Five-twelfths natural size.
FIG. II.—Etched surface, reduced one-fifth.



Meteoric Iron, collected near Cañon Diablo, Arizona, June, 1891.
Larger mass weighing 201 lbs., completely perforated in three places.

Plate XIV.

places.



Polished Surface of Meteoric Iron from Cañon Diablo, Arizona, showing Widmanstättian figures. A small black diamond is shown protruding near one side of the central black cavity, at D; a circle of scratches made by small loosened diamonds can be seen near this spot.

BECKER BROTHERS,

No. 6 Murray Street, New York,

Manufacturers of Balances and Weights of Precision for Chemists, Assayers, Jewelers, Druggists, and in general for every use where accuracy is required.

A UNIVERSAL ENGLISH-GERMAN AND GERMAN-ENGLISH DICTIONARY.

By Dr. Felix Flugel.

4th edition, thoroughly revised, of Dr. J. G. Flügel's Complete Dictionary of the English and German Languages.

Complete in 12 numbers of 14 signatures each; a number appears monthly. Subscription price for each number, 3 Marks.

George Westermann, Braunschweig, Germany.
B. Westermann & Co., New York City.

UNIVERSITY OF TEXAS,

AUSTIN, TEXAS.

The Board of Regents having recently established an Assistant Professorship of Biology, temporarily in connection with the Chair of Geology, applications and testimonials may now be addressed to Regent F. W. Ball—care of Ball, Temple and Ball, Fort Worth, Texas. The salary will be $2,000 per annum and prominence will be given to Botany.

AMERICAN JOURNAL OF SCIENCE.

Founded by Professor Silliman in 1818.

Devoted to Chemistry, Physics, Geology, Physical Geography, Mineralogy, Natural History, Astronomy, and Meteorology.

Editors: James D. Dana and Edward S. Dana.

Associate Editors: J. P. Cooke, Jr., George L. Goodale, and John Trowbridge, of Cambridge, H. A. Newton and A. E. Verrill, of Yale, and G. F. Barker, of the University of Pennsylvania, Philadelphia.

Two volumes of 480 pages each, published annually in **MONTHLY NUMBERS.**

This Journal ended its *first* series of 50 volumes as a quarterly in 1845, and its *second* series of 50 volumes as a two-monthly in 1870. The monthly series commenced in 1871.

Twenty copies of each original communication are, *if requested, in advance* struck off for the author without charge; and more at the author's expense, provided the number of copies desired is stated on the manuscript or communicated to the printers of the Journal.

The title of communications and the names of authors must be fully given. Articles should be sent in two months before the time of issuing the number for which they are intended. Notice is always to be given when communications offered have been, or are to be, published also in other Journals.

Subscription price $6; 50 cents a number. A few sets on sale of the first and second series.

Ten-volume index numbers on hand for the second and third series. The index to volume xxxi to xl (3d series) was issued in January, 1891; price 75 cents.

Address the Proprietors,

J. D. and E. S. DANA, New Haven, Conn.

TSCHEFFKINITE.

Our Mr. English has just returned from a very successful trip to North Carolina, where he visited a number of important localities and we announce the results as follows :

Tscheffkinite, the excessively rare silico-titanite of the cerium earths, etc., in fine masses, 50c. to $5.00 ; small specimens, 10c. to 35c.

Gem Oligoclase, transparent, very rare and interesting, 25c. to $2.00 ; small clear pieces, 10c. For description see this Journal, September and November, 1888.

Beryl Crystals, terminated, loose and in the matrix, 10c. to $1.00.

Gummite, Uranotile, and Uraninite, beautifully combined in the specimen, 50c. to $2.50.

Samarskite, good masses, 25c. to $1.00.

JAPAN.

We have just received a lot of fine Topaz crystals which were especially selected for us in Japan, from a great quantity of crystals, at our request, by a prominent American mineralogist, who visited that country this summer. The largest crystal is three inches long and two and half inches thick. A number of the crystals are especially interesting on account of being curiously etched. Large crystals, $5.00 to $12.50 ; small ones, averaging ¾ inches in length, but interesting form, 50c., 75c., and $1.00.

RARE SILVER MINERALS.

We can supply the following rare Silver Minerals in good specimens at prices quoted. They are all well crystallized except Native Silver, Polytelite and Argyrodite.

Native Silver, Freiburg, Saxony, 75c. to $3.00.
Argentite, Freiburg, Saxony, 75c. to $5.00.
Acanthite, Freiburg, Saxony, $1.50 to $3.00.
Sylvanite, Nagyag, Hungary, $2.50 to $5.00.
Pyrargyrite, Freiburg, Saxony, 75c. to 2.50.
Proustite, Freiburg, Saxony, 75c. to $3.00.
Polytelite, Freiburg, Saxony, 75c. and $3.50.
Stephanite, Freiburg, Saxony, 75c. to $3.50.
Polybasite, near Lawson, Colorado, 25c. to $2.50.
Aguilarite, Guanajuato, Mexico, $1.00 to $10.00.
Argyrodite, Freiburg, Saxony, $3.50 to $5.00. This is the only known mineral containing Germanium.

"CATALOGUE OF MINERALS AND SYNONYMS,"

by Prof. THOS. EGLESTON, handsomely bound in cloth, $2.50 ; postage, 16c. extra.

"TABLES FOR THE DETERMINATION OF MINERALS,"

by Prof. PERSIFOR FRAZER, bound in cloth, $2.00 ; postage, 5c. extra.

"ELEMENTS OF CRYSTALLOGRAPHY,"

by Prof. GEORGE H. WILLIAMS, bound in cloth, $1.25 ; postage, 10c. extra.

GEO. L. ENGLISH & CO., Mineralogists,

733 & 735 Broadway, New York.

CONTENTS.

Page

ART. XXXIV.—The Solution of Vulcanized India Rubber; by CARL BARUS 359

XXXV.—Report of the Examination by means of the Microscope of Specimens of Infusorial Earths of the Pacific Coast of the United States; by A. M. EDWARDS 369

XXXVI.—The Tonganoxie Meteorite; by E. H. S. BAILEY. With Plate XIII 385

XXXVII.—Proposed Form of Mercurial Barometer; by W. J. WAGGENER 387

XXXVIII.—Color Photography by Lippmann's Process; by C. B. THWING 388

XXXIX.—New Analyses of Uraninite; by W. F. HILLEBRAND 390

XL.—The Tertiary Silicified Woods of Eastern Arkansas; by R. ELLSWORTH CALL 394

XLI.—Occurrence of Sulphur, Orpiment and Realgar in the Yellowstone National Park; by W. H. WEED and L. V. PIRSSON 401

XLII.—Mineralogical Notes; by L. V. PIRSSON 405

XLIII.—Peridotite Dikes in the Portage Sandstones near Ithaca, N. Y.; by J. F. KEMP 410

XLIV.—New Locality for Meteoric Iron with a Preliminary Notice of the Discovery of Diamonds in the Iron; by A. E. FOOTE. With Plates XIV, XV 413

XLV.—The South Trap Range of the Keweenawan Series; by M. E. WADSWORTH 417

XLVI.—Geological Facts noted on Grand River, Labrador; by A. CARY 419

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics—So-called "Black Sulphur" of Magnus, KNAPP, 422.—New form of Silicon, WARREN: New Alkaloid from Conium maculatum, LADENBURG and ADAM, 423.—Iron-tetracarbonyl and Nickel-tetracarbonyl, MOND and QUINCKE, 424.—Sensitive Reaction for Tartaric acid, MOHLER, 425.—Photography of the Spectrum in natural color, VOGEL: Discharge of Electricity through exhausted tubes without electrodes, THOMSON, 426.—Ratio of Electromagnetic to Electrostatic units, THOMSON and SEARLE: Expansion of Water: Experiments in Aerodynamics, LANGLEY, 427.—Chemical Analysis of Iron, BLAIR, 428.—Die Fortentwickelung der elektrischen Eisenbahn-Einrichtungen, KOHLFÜRST, 429.

Geology and Mineralogy—Report of Exploration of the Glacial Lake Agassiz in Manitoba, W. UPHAM, 429.—Geological Survey of Texas, 2d Annual Report, 1890, E. T. DUMBLE: Preliminary Notice of a New Yttrium-Silicate, W. E. HIDDEN, 430.—Anatase from the Arvon Slate Quarries, Va., G. H. WILLIAMS, 431.—Ilvaite, G. CH. HOFFMANN: Synthese du Rubis, E. FREMY, 432.—Brief notices of some recently described minerals, 433.—Catalogue of Minerals and Synonyms, T. EGLESTON, 434.

Botany—Some Museums and Botanical Gardens in the Equatorial Belt and the South Seas, 434.

Miscellaneous Scientific Intelligence—Leidy Memorial Museum: Bibliotheca Zoologica, O. TASCHENBERG: Catalogue of Minerals, 438.